The Impact of Urban Form on Older Adults: Focusing on Neighborhood Design and Baby Boomers' Local Behavior

By

Jae Seung Lee

Bachelor of Fine Arts, Department of Industrial Design, Seoul National University, 1997
Bachelor of Science in Engineering, Department of Architecture, Seoul National University, 2000
Master of Architecture / Master of Urban Design, University of Michigan, 2008

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Author ____
Department of Urban Studies and Planning
May 2012

Certified by ____
Professor Eran Ben-Joseph
Department of Urban Studies and Planning
Dissertation Supervisor

Accepted by ____
Professor JoAnn Carmin
Chair, PhD Committee
Department of Urban Studies and Planning

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Abstract

The growing share of older adults across the globe raises concern about active and safe aging. This dissertation examines aging baby boomers' travel and social behavior resulting from neighborhood design. The body of the research consists of three interrelated essays:

The first essay explores age-restricted neighborhoods that target persons 55 and over, providing age-targeted physical design and social services. This study aims to offer insights into how this suburban morphology has evolved, as well as its impacts on travel behavior of baby boomers living in age-restricted neighborhoods. The study compares several physical characteristics, walkability, and local activity levels of five representative age-restricted neighborhoods and five nearby ordinary neighborhoods in Massachusetts. The analysis finds that, while providing diverse neighborhood amenities, age-restricted neighborhoods remain automobile-dependent due to the poor street connectivity and the lack of potential nearby destinations.

The second essay analyzes the travel behavior, residential choices, and related preferences of 55+ baby boomers in suburban Boston, looking specifically at age-restricted neighborhoods. For this highly auto-dependent group, do neighborhood-related characteristics influence local-level recreational walk/bike and social activity trip-making? The analysis aims to discern community (for example, social network) versus physical (for example, street network) influences. The analysis reveals modest neighborhood effects. Living in age-restricted, as opposed to un-restricted, suburban neighborhoods modestly increases the likelihood of being active and the number of local social trips. Overall, the age-restricted community status has greater influence on recreational and social activity trip-making than the neighborhood physical characteristics, although some community – neighborhood interaction exists.

The third essay seeks to reveal the interactions between urban form and safety affecting urban baby boomers' walking behavior. Spatial analysis reveals the traffic accident patterns in urban Boston neighborhoods, indicating hotspots around activity centers. The analysis identifies significant effects of walkable urban forms (e.g., mixed use, well-connected streets, and good access to potential destinations) on older adults' walking. Yet accessibility to retail, as well as traffic speed and volume, are positively associated with the traffic accident frequency. The result implies a potential health trade-off between neighborhood walkability and safety, at least for urban baby boomers.

Note: Parts of this dissertation have been published in the following journals and conference proceeding:

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Title: Professor of Landscape Architecture and Urban Planning

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Abbreviations

AARP	American Association of Retired Persons
ARAAC	Age-Restricted Active Adult Community
ESRI	Environmental Systems Research Institute
FAR	Floor Area Ratio
FHA	Fair Housing Act
GIS	Geographic Information System
HOPA	Housing for Older Persons Act
HUD	Department of Housing and Urban Development
ICT	Information and Communication Technology
MAUP	Modifiable Areal Unit Problem
NHTSA	National Highway Traffic Safety Administration
NMT	Non-Motorized Transport
NORC	Naturally Occurring Retirement Community
PCA	Principal Component Analysis
SEM	Structural Equation Modeling
TAZ	Traffic Analysis Zone
ZINB	Zero-Inflated Negative Binomial

Definitions

Age-restricted Neighborhood:	A community where at least 80% of the units must be occupied (not owned) by at least one person 55 years of age or older or a community where 100 % of the units are occupied by persons 62 years of age or older. Most of the age-restricted community associations fall into the 55 plus category.
Un-restricted Neighborhood:	Ordinary suburban neighborhood without age-restriction
Leading-edge Boomers:	People who aged 55 to 64
Older Adults:	People who aged 55 and older

Chapter 1

Overview: Neighborhoods for Aging Baby Boomers

1.1. Global Aging

Globally, the growing numbers of older adults, combined with changes in metropolitan settlement patterns, have profound implications for urban futures (Champion, 2001). While countries are in different stages of the process of aging, the global population age 60 and older was approximately 680 million people in 2009, making up 11 percent of the world's population. By 2050, this age cohort will increase from 680 million to 2 billion, increasing from 11 to 22 percent of the world's population.[1] Life expectancy has also dramatically increased since the mid-1800s, due to reduced mortality driven by improvement in sanitation and medicine, as well as by innovations in industrial and agricultural production and distribution (Kinsella & Phillips, 2005). These unprecedented rates of global aging and life expectancy increase have raised challenges to older adults' active and healthy lifestyle, leading to fundamental questions: are longer life expectancies accompanied by better quality of life, or do they imply more years of sedentary and unhealthy life? How should cities provide this rapidly growing older population with enabling and supportive environments?

"Aging" refers to a process of physical, social, psychological, and economic changes that people experience over time. While the term, "older adult," generally indicates a person who is aging, it includes inherent diversity. For instance, many people are 65 and older maintain their physical and economic conditions very well and do not want to be labeled as "older adults" or "seniors." Hence, there is no consensus on terms to describe people considered old. However, a general classification is useful for inter-generation and inter-state comparison. In general, people aged 55 to 64 are often referred to as the "pre-senior" or "pre-retiree" group (Frey, 2003). The group who age 65 and older includes two sub-

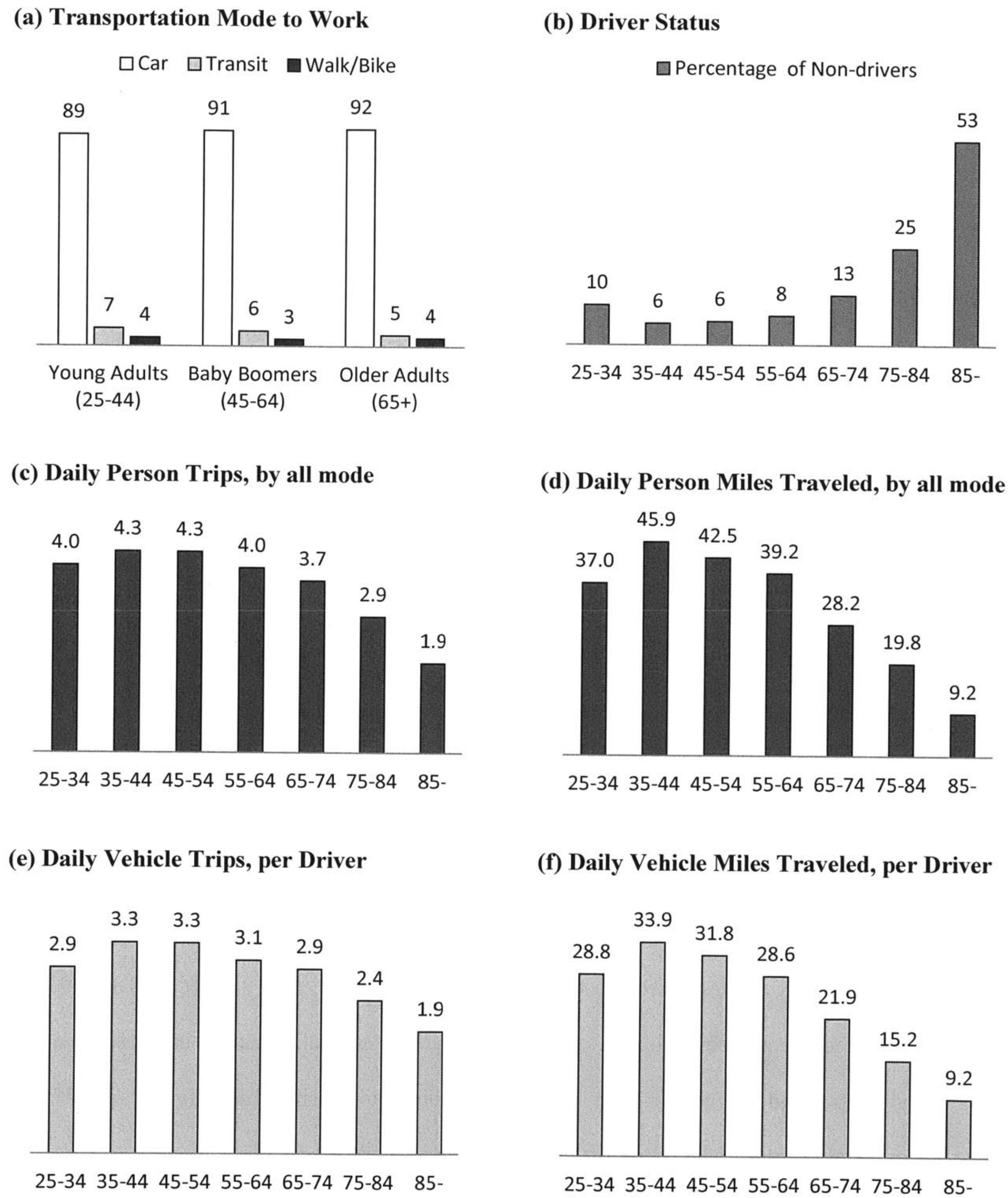
[1] United Nations, 2009.

categories: the "old (65-79)," the "oldest-old (80+)" (Kinsella & Phillips, 2005). In particular, the first wave of aging baby boomers in the US, who are the pre-senior group, reach full retirement age in 2011. For the next 20 years, 78.2 million baby boomers will join the “young old” group. In this chapter, “baby boomers” refers to this leading-edge cohort (55 to 64) while “older adults” refers more generally to those 55+.

1.2. Aging Baby Boomers in Suburbia

In many industrialized countries, “baby boomers” – the generation born during the period of sustained high birth rates following World War II – are now associated with distinctive approaches to consumption, politics, personal finance, work and retirement, health and leisure (Phillipson et al., 2008). In the US, the baby boomers (born between 1946 and 1964) comprised approximately one quarter of the total population in 2005 (Heudorfer, 2005). Many of the baby boomers were the first to be born and raised in the proliferating postwar suburbs. Currently, the majority of baby boomers reside in automobile-dependent suburban locations: 77 percent of older adult (55+) households are located in suburbs or outside metro areas (Emrath & Liu, 2007). Baby boomers tend to be heavily dependent on automobiles for their travel: for example, their mode share of automobiles for commuting to work is approximately 91 percent (Figure 1-1a). This automobile dependency can lead to mobility problems in the future, because many baby boomers are expected to cease driving, as the percentage of non-drivers increases rapidly after age 65 (Figure 1-1b). Also, aging entails inevitable physical and social changes, including diminished physical abilities and social engagements. Consequently, baby boomers’ activity levels are likely to rapidly decrease after they retire: the frequency and distance of their trips, both by all modes (Figure 1-1c and 1-1d) and by automobile (Figure 1-1e and 1-1f), tend to diminish after 65.

Figure 1-1. Analysis of Baby Boomers' Travel Behavior



(Source: 2009 National Household Travel Survey)

As suburban neighborhoods are generally automobile-dependent, having few destinations and poor public transit services, baby boomers in suburbs are likely to have more difficulties in maintaining their mobility as they age. However, evidence suggests that while many baby boomers have concerns regarding their current neighborhoods becoming unsuitable for them, it is unlikely that they are willing to give up the privacy of their suburban environment, nor the conveniences and social contacts with neighbors (Zegras et al., 2008). These conflicting attitudes challenge designers, planners, and developers to understand baby boomers' preferences, in order to improve current environments or provide residential options that offer active and sustainable lifestyles.

1.3. Housing Options for Baby Boomers

A challenge for aging baby boomers is the lack of housing options that can satisfy their needs and desires. Two basic categories of older adult neighborhoods can be identified. First, unplanned communities (aging in place) – i.e., "naturally occurring retirement communities" (NORCs) that organically evolve into neighborhoods with the majority of residents aged 55 and older (Hunt and Gunter-Hunt, 1985). The second category is planned developments, which include continuing care retirement communities offering on-site nursing/care facilities; leisure-oriented retirement communities, typically built around recreation (for example, golf courses); and skilled nursing care that provides comprehensive 24-hour nursing service. Given these elderly housing options, the increasing share of the aging population raises challenges that require planning and policy actions to provide affordable, aging-friendly housing and services. For older adults who continue to live in their own homes as they age, planners and policy makers may need to assist with home modification and service provision. Another challenge is to expand affordable and supportive housing choices for older adults who need to relocate (Lipman et al., 2012).

1.4. Age-Restricted, Active Adult Communities

Among the planned developments, age-restricted, active adult communities[2] for persons 55 and over are a recently emerging residential option for baby boomers (Gentile, 2006; Heudorfer, 2005). While other types of planned developments serving inactive or frail persons are less attractive to wealthy and healthy baby boomers, age-restricted, active adult communities target this active age cohort. In the US, the age-restricted, active adult community is legally allowed to restrict their residents' ages to 55 and older, in order to provide a socially supportive environment exclusively for the aging population. The legal ground of this development type is the Housing for Older Persons Act of 1995 (HOPA), which defines requirements for the age-restricted status. Age-restricted, active adult communities are typically for-sale homes on smaller lots. They are relatively affordable and require less maintenance. Such developments include distinctive social and physical features that distinguish them from ordinary suburban developments: for example, common recreational facilities (e.g., golf courses, walking paths, or community centers) and other social programs (e.g., peer groups or medical services) (Suchman, 2001). These age-restricted neighborhoods offer a unique opportunity to empirically examine the effects of physical design and social setting on aging baby boomers in suburbs. Hereafter, "age-restricted neighborhoods" refer to age-restricted, active adult communities and "un-restricted neighborhoods" refer to typical suburban developments without explicit age restrictions.

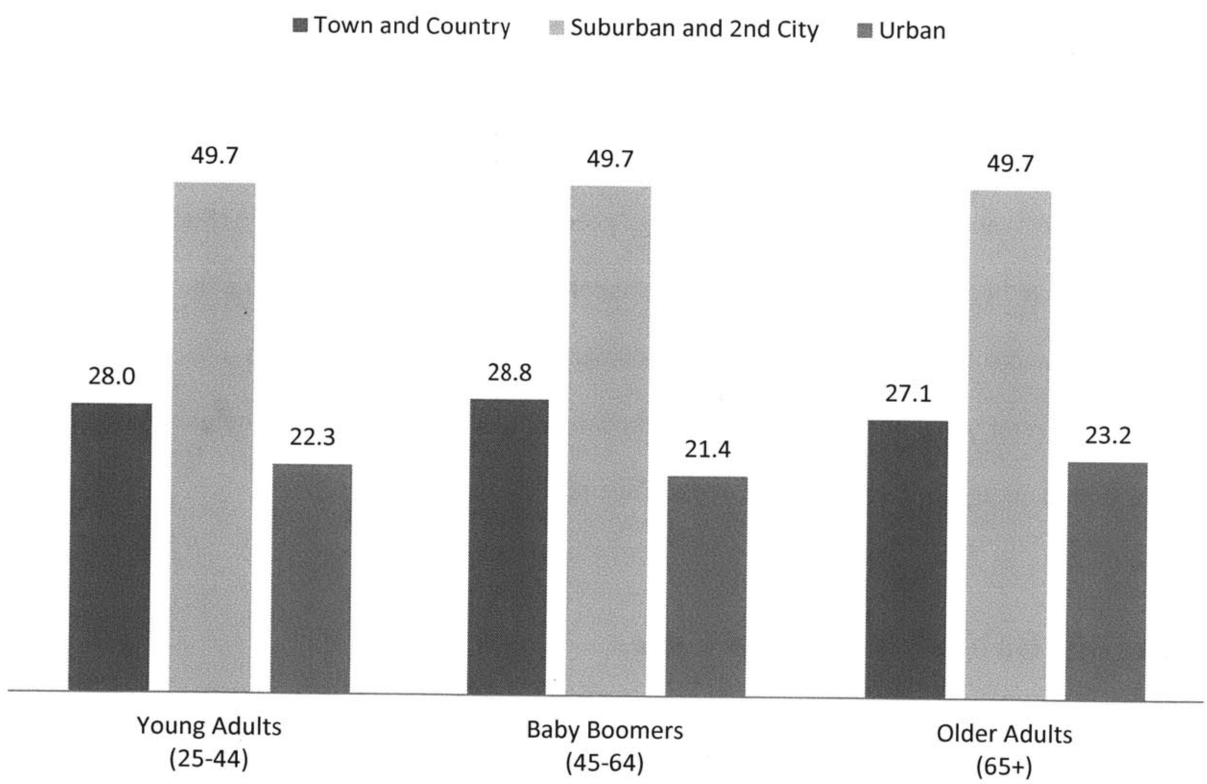
1.5. Aging Baby Boomers in Cities

Despite the majority of baby boomers living in suburbs and towns, a significant proportion resides in urban areas. According to the 2009 National Household Travel Survey, 21 percent of baby boomers are living in urban areas (Figure 1-2); other baby boomers are in "suburban and 2nd city" (50 percent) or "town and country" (29 percent). Urban baby boomers' travel pattern is less automobile-dependent, relative to their suburban counterparts: baby boomers' mode share of automobiles in urban areas is 75

[2] In the US, the Department of Housing and Urban Development (HUD) uses senior housing, or 55 and older community; residential developer Del Webb refers to "active adult communities" (Harris Interactive, 2005); the National Association of Homebuilders suggests that "age-qualified" is preferred (Emrath and Liu, 2007).

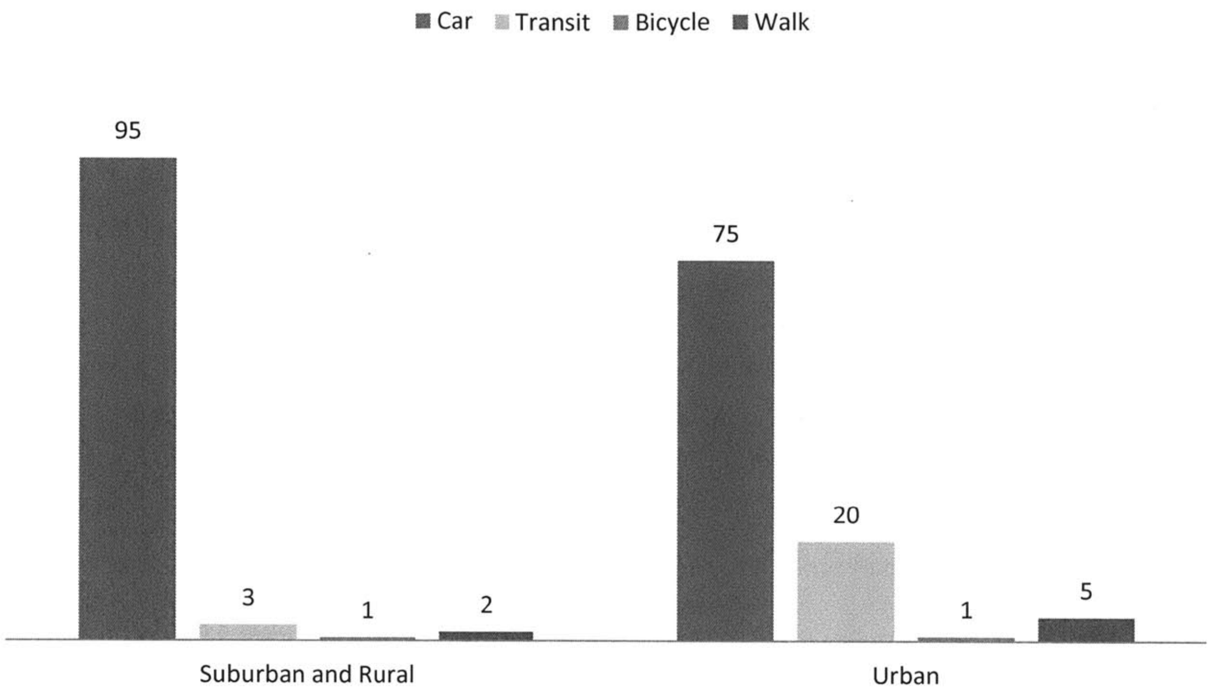
percent, while that in suburban areas is 95 percent (Figure 1-3). Also, urban neighborhood characteristics, such as density, diversity of uses, accessibility to potential destinations, and provision of transportation services, are quite different from suburban environments. In particular, urban baby boomers are exposed to greater traffic volume in city centers, and therefore, a potentially higher level of traffic accidents. Hence, examining the influence of urban environment on baby boomers' travel behavior and safety can offer insight into how urban neighborhoods influence their residents differently from suburbs.

Figure 1-2. Residential Locations in the US (percent)



(Source: 2009 National Household Travel Survey)

Figure 1-3. Baby Boomers' Mode Choice by Urban and Suburban Residential Location (percent)



(Source: 2009 National Household Travel Survey)

1.6. Implications of Urban and Suburban Residential Locations

Given the socio-demographic geography of baby boomers in the US, this dissertation empirically investigates urban and suburban baby boomers' local travel and social behavior independently. This section generally discusses implications of living in urban versus suburban areas. It introduces definitions of the two terms, "urban" and "suburban," and traces how the two concepts have evolved.

Urban and Suburban

While a division of "urban" and "suburban" is one of the most frequent ways to characterize human settlements, neither of the terms is entirely straightforward. Early cities, in most cases walled settlements, were the antithesis of rural areas. However, the expansion of cities over the walls toward rural areas introduced a new form of settlement, "suburb," which means literally "beyond the city" (Fishman 1986). Thus, suburbs can ambiguously represent any human settlements at the fringe of cities. These ambiguities of the two terms – urban and suburban – are rooted in multiple and complex aspects of human settlements, such as physical form and social structure, and the relationship between the two.

Fundamentally, urban settlement is characterized by the concentration of people and activities in certain areas, which can be referred to as "high density." Density is a basic quality for urban-ness because it is the potential property of clusters of human settlements, such as towns and cities, where inhabitants interact with other individuals and institutions in proximity (Lozano 1990). Yet there are many ways to define "urban area" – for example, by urban form, by activity patterns, or by population. While each country has its own definition of urban area, in the United States, the Census Bureau defines an urban area as "core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile." Gillham (2002) analyzed residential density in terms of dwelling units per acre and floor area ratio (FAR) and defined urban areas as having at least 24 dwelling units per acre or a minimum FAR of 0.88. However, these definitions are not sufficient to capture a variety of characteristics and social implications of "urban" and "suburban" areas.

Urbanism

Debates on the origin and nature of cities fall roughly into two categories: (1) agglomeration by economic and functional revolution and (2) agglomeration for social and spiritual values. V. Gordon Childe, an archaeologist, explained the historical development of humanity through three revolutions – the Neolithic, the Urban, and the Industrial Revolution – that are related to the development of production and trade. In his view, cities emerged during the Urban Revolution, the shift from neolithic agriculture to complex manufacturing and trade (Childe 1936). Jane Jacobs (1961) also regarded surplus wealth and productivity as the catalysts of big and dense cities. She viewed agricultural surplus around cities as contributing to the growth of city centers. Indeed, proximity to labor, capital, and materials, as a result of agglomeration in cities, has been beneficial to economic activities. Cities have made it possible to reduce transport costs for people and goods, as well as ideas, and to benefit from economies of scale. But Lewis Mumford (1961), in contrast, valued the human spirit in societies over economic benefits. It was inadequate for him to define cities in terms of population size, economic activities, or characteristics of the built environment. Rather, he defined the city as a "theater of social action," in which a variety of social activities, what he called "social drama," take place (Mumford 1937). Kevin Lynch (1984) also stressed the spiritual aspects of cities: as places of ritual and pilgrimage that released anxieties about fertility, death, and the continuity of human communities. These spiritual places played an important role in the revolution from villages to cities. Although these two perspectives (economic and spiritual) on the origin of cities seem to contradict each other, no one would deny that the nature of cities embraces all these factors.

The discussions about the nature of cities have included their physical and social aspects. Louis Wirth, a member of the Chicago school of sociology, formulated a sociological definition of "urbanism," looking beyond the physical structure or economic functions of cities. He defined a city as minimally "a relatively large, dense, and permanent settlement of socially heterogeneous individuals" (Wirth 1938). Based on this definition, three characteristics of cities – population size, density, and heterogeneity – are fundamental to the urban way of life. He was generally critical about the effects of these characteristics. The increasing number of people in a settlement affects the relationship between the individual and the characteristics of city life. Urbanites are socially related to a greater number of people, and more dependent on others, than rural people. But they are less dependent on particular persons, and their dependency tends to be confined to specific aspects of persons, mostly related to their role in society. This implies that the relationships between people in cities can be generally characterized as secondary rather than primary contacts, and therefore, the contacts are impersonal, superficial, and segmental. An increase in density also tends to create differentiation and specialization, which produce living together without sentimental and emotional ties. Social heterogeneity also destabilizes social structures in cities and tends to make relationships transient.

In contrast, Jane Jacobs (1961) celebrated urban characteristics (size, density, and heterogeneity) as essential factors of human settlement. In her perspective, the presence of many people, including even strangers, is a sign of healthy and active cities. Diversity (or heterogeneity) is also a positive and essential attribute of cities, because people who live in diversified rather than homogeneous districts can have more choice and flexibility so as to adjust themselves when physical and social changes take place. Therefore, Jacobs advocated concentrated and mixed-use neighborhoods with small blocks and "aged buildings" that can accommodate diversity. Herbert Gans similarly criticized Wirth's conception of urbanity: Wirth's conclusion was too constrained to findings from "transient zones" to be generalized to entire urban areas and disregarded urbanites who are able to maintain and develop their culture by living in cities, for example, "urban villagers" in New York's Lower East Side, who keep kinship and primary contacts and rely less on secondary contacts. Therefore, a simple dichotomy of primary and secondary contacts is not valid; rather the urban way of life is more complex and quasi-primary (Gans 1962). He examined the West End of Boston, generally regarded as a slum (from Wirth's point of view, for example), and concluded that urban villages like the West End are not just bad places, but rather largely good places to live for diverse groups of people, resisting mass-produced homogeneous American culture, despite their humble and messy environments (Gans 1982).

Suburbanism

The terms, "suburbs" and "suburbia" are used to refer to residential communities beyond city centers. While physically separated from city centers, suburbs are economically and culturally dependent on jobs and amenities in the core of cities. The principles of suburbs are domesticity, privacy, and class segregation. Influenced by the English evangelical movement, proponents of suburbs thought that family life should be separated from the world of work, and moved to a more natural environment in order to achieve the suburban ideal. Thus, suburbia includes only middle-class residents, excluding (1) industries and commerce which may hurt domesticity, (2) high-density or multi-family housing that would threaten privacy, and (3) lower-class residents, in order to maintain class segregation (Fishman 1986).

The ideal residential environment of suburbs is a harmony between nature and town. Frederick Law Olmsted's design of Riverside, Illinois, epitomizes the true suburban design. Olmsted was influenced by the English picturesque and believed that bringing nature to human settlements cures urban ills. He was able to realize his aesthetic by designing a picturesque urban park, New York's Central Park. Although his first work is located in the core of New York, he advocated suburbs as "the most attractive, the most refined, and the most soundly wholesome form of domestic life." Although the "nature" in Riverside, for example, curvy pathways around hills and trees, is artificially constructed, its environments are subtle enough to create the sense of harmony with nature. Also, Olmsted sought to achieve balance between domesticity and community; his aim was "pleasant openings and outlooks, with suggestions of refined domestic life, secluded, but not far removed from the life of community." He designed public spaces, such as village greens, playgrounds, and ball grounds, to provide "the life of community." Furthermore, he suggested – although this part of his vision was not realized – wide and landscaped pleasure drives with flows of elegant carriages and riders, so as to accommodate congregated "urban delight" (Fishman 1986). When these ideals were combined with American individualism, laissez-faire economics, and zoning and subdivision regulations, as well as mass-production and mass-consumption culture, American suburbs rapidly expanded. This phenomenon is often called "sprawl," which can be characterized as unplanned, single-use, leap-frogging development at the peripheries of cities (Bruegmann 2005).

Suburbanization in the United States has provoked academic debates, and much of the literature about suburbanization has been critical, regarding suburbs as cultural wastelands and ecological disasters. In this view, suburban life failed to deal with conflict between groups, such as upper-middle-class and lower-class, adults and children, male and female, and different ethnic groups. Therefore, pluralism is often strictly limited in suburbs; life styles disliked by upper-middle-class suburbanites are generally rejected. Inclined toward individualism and domesticity, suburbanites tend to refuse to reconcile the rights of the person and the family with public service and common benefit. However, some critics, such as Herbert Gans (1962), held a sympathetic view of suburbs. He described the way of life in suburbs as quasi-primary – similar to the urban way of life – meaning that the social interactions between suburbanites were more intimate than a secondary contact, but more guarded than a primary one, regardless of the intensity or frequency of these relationships. In suburbs – e.g., postwar traditional suburbia – there were few secondary relationships due to the isolation of single-use residential areas from workplaces. For instance, shopkeepers or store managers are often perceived as acquaintances in small towns. Gans argued that since social contacts in both cities and suburbs are quasi-primary, the problems observed in suburbs should not be attributed to the suburban settings; individuals may have chosen suburbs in order to obtain their desired life style. Furthermore, he observed the lives of Levittowners and concluded that Levittown is not a cultural wasteland, despite many problems: Levittowners are much more "in the world," accepting differences and public needs, than their ancestors (Gans 1967).

Urbanism versus Suburbanism

The most frequently cited differences between urban and suburban areas are: (1) suburbs are more likely to be single-use bedroom communities; (2) suburbs are farther away from amenities in city centers; (3) suburbs are designed for automobiles rather than for pedestrians and mass transit; (4) suburbs are built up with single-family rather than multi-family housing and are therefore less dense; (5) suburban demography is more homogeneous; and (6) suburban populations are younger, richer, and more likely to hold white-collar jobs. Yet Gans (1962) argued that the differences are exaggerated; most urban communities except old city centers are single-use bedroom communities without sufficient transit access, similar to suburbs. Furthermore, there have been attempts to understand decentralized postmodern cities as a new kind of cities that are neither traditional cities nor suburbs. These new cities – known as edge cities (Garreau 1991) or technoburbs (Fishman 1986) – no longer depend on traditional city centers, instead taking advantage of the advances of transportation and communication technology. They achieve higher density than traditional suburbs and include jobs and entertainment. Fishman emphasizes the need for exploring this new urbanity, arguing that "for those of us who value urbanity, there is no choice but to accept the complex challenges of the new city and to seek out urbanity where we find it" (Fishman 1994).

1.7. Mobility versus Accessibility

These residential locations in urban and suburban areas are closely related to the concepts of "mobility" and "accessibility" characteristics, which have profound implications for older adults' well-being and quality of life. While the terms "mobility" and "accessibility" are often used interchangeably in the fields of transportation and urban planning, the distinction between the two is important. Researchers have defined the two terms in different ways. In a transportation planning context, mobility is generally defined as the potential for movement, the ability to move from one place to another (Handy 2002). Mobility is usually measured by throughput and capacity of transportation systems, such as the level-of-service, frequency of trips, and total miles traveled. Accessibility, on the other hand, implies the potential for activities and interactions; Geurs and van Wee (2004) defined it as "the extent to which land-use and transport systems enable (a group of) individuals to reach activities or destinations by means of a (combination of) transportation modes." Measures of accessibility include both impedance factors (generally transportation-related), such as travel time and cost, and attractiveness factors (generally land use-related), such as the quantity and quality of destinations. Therefore, available choices in both modes of travel and destinations are crucial elements of accessibility (Handy and Niemeier 1997).

Although mobility and accessibility are closely related, the relationship between the two is not straightforward. In other words, higher mobility does not necessarily mean higher accessibility. For example, a neighborhood with sufficient roads and low levels of congestion without adequate quality and quantity of destinations has good mobility yet poor accessibility. On the other hand, there can be a case of good accessibility but poor mobility. For instance, a neighborhood with high levels of congestion but ample and desirable destinations within a walking distance has poor mobility yet good accessibility. Therefore, good mobility is neither a necessary nor sufficient condition of good accessibility (Handy 2002).

In general, accessibility can be understood as a benefit, well-being, or end of transportation and land use planning, whereas mobility can be regarded as a means of providing accessibility. Sometimes, mobility can be an end per se, for example, when one drives in order to enjoy driving and speed. Therefore, accessibility has become a key idea that characterizes fundamental principles of human activity (Pirie 1979). Reliable measures of accessibility are important for urban and transportation planners. This is because the distribution of accessibility across an urban area shows the balance and competition among districts and neighborhoods, revealing equity or inequity in terms of well-being as well as integration or segregation of social groups.

However, accessibility is an ambiguous notion; it is not easy to define and measure accessibility. Among different definitions, four components of accessibility are identified: land-use, transportation, temporal, and individual components (Geurs and van Wee 2004). First, land use components consist of (1) the amount, quality, and distribution of opportunities, supplied by land use system, (2) the demand for these opportunities at origins of travel, and (3) the competition for activities within restricted capacity. In general, the more and better opportunities within a same distance, the better the accessibility. Also, the closer opportunities imply the better accessibility. Second, transportation components are expressed as disutility (impediment factors). Transportation components include travel time, cost, and quality of travel (reliability, level of service, and accident risk). Third, temporal components reflect the availability of opportunities, depending on different times (in a day, week, or year). For instance, recreational facilities may not be available for employees during working hours. Fourth, individual components include different needs, abilities, and socio-economic status of individuals. These characteristics influence the level of accessibility, available for individuals. For example a person with better health or income can have more opportunities.

These four components are dynamically related to one another. Influencing one component of accessibility also affects other components through complex feedback mechanisms: for instance, an increasing number of destinations can improve accessibility, but more destinations can attract more traffic and therefore increase levels of congestion, which may eventually result in decreased accessibility by increasing traffic time.

1.8. Measures of Accessibility

In order to capture this multi-dimensionality of accessibility, researchers have developed a variety of measures. Accessibility measure can be categorized into four types of measure: infrastructure-based, location-based, person-based, and utility-based (Geurs and van Wee 2004; Handy and Clifton 2001; Handy and Niemeier 1997; Pirie 1979; Ingram 1971).

First, infrastructure-based measures, typically used in transportation planning, analyze the performance of transportation infrastructures, such as average travel time and level of congestion. However, infrastructure-based measures have shortcomings in the evaluation of social and economic effect of accessibility because they ignore the effect of land use components.

Second, location-based measures analyze the effect of opportunities at locations. Among these, cumulative opportunity (or distance) measures count the number of opportunities within a given distance (either straight line distance or isochorne) or travel time. Although the distance and the number of opportunities are straightforward and easy to interpret, distance measures fail to take into account the competition effect among destinations, and to account for people's perceptions of the qualities of destinations. This is why gravity-based measurement incorporates distance as a decaying function into the estimation of accessibility, assuming smaller and more distant opportunities exert smaller influence.

Gravity-based measures overcame some shortcomings of distance measures, by combining land use (destinations) and transportation (distance) components, and by accounting for person's perception of transport. Therefore, the gravity-based approach is a fairly reasonable measure of accessibility and its social and economic impact, although still weak in accounting for temporal components.

Third, person-based measures analyze accessibility at an individual level. Person-based measures take into account the availability of "activities in which an individual can participate at a given time." Person-based measures, originated in Hägerstrand's (1970) time-space framework, aim to incorporate individuals' time and space budgets. This is because individual activities are constrained not only by spatial distance but also by the available time people can spend in activities. While conceptually appealing, person-based measures have been limited in their applications due to insufficient data and computational difficulties.

Lastly, utility-based measures analyze the benefits from access to the spatially distributed activities. Utility-based measures are rooted in random utility theory. The probability of an individual making a particular choice depends on the utility of that choice relative to the utilities of all choices (expected maximum utility). Utility-based measures are the sum of utilities of all choices, which typically come from the denominator of multinomial logit models (logsum). The strength of utility-based measures is that utility-based measures are able to assess accessibility, taking into account both transportation and land use changes. The disadvantages of utility-based measures are the difficulties in interpretation and communication. Since the logsum values are inherently unit-less, it is difficult to interpret them without an appropriate base-value or frame of reference. Furthermore, communication with policy makers and other planners, who are not usually familiar with complex theories, is another challenge. It is important to translate utility-based measures into easily understandable forms.

1.9. The Elderly Travel Behavior and Accessibility

These mobility/accessibility characteristics are closely related to older adults' well-being and quality of life. Carp (1980) defined social and emotional well-being of the elderly as the presence of positive self-esteem and feelings of happiness, as well as the absence of loneliness, anxiety, and depression. He suggested that well-being depends on the degree to which individuals can match their needs to neighborhood resources and mobility/accessibility. For instance, in order to achieve older adults' well-being, their life-maintenance needs, such as foods, doctors, and medicine should be satisfied by the access to life maintenance resources, such as groceries, hospital, and pharmacies. Similarly, mobility and accessibility to family, neighbor, and recreational places are important to satisfy higher-order needs, such as socializing and recreation. Therefore, mobility and accessibility are key determinants that significantly affect older adults' well-being.

The qualities of elderly mobility and accessibility that influence well-being include their feasibility, safety, and controllability. Decreased physical abilities of the elderly threaten the feasibility of mobility/accessibility. Deteriorated visual ability makes it difficult for the elderly to drive at night, or at high speeds, or through unfamiliar places. In addition, public transportation also requires a certain level of agility, strength, and speed, which can be less feasible for older riders. Decreased walking-ability can make walking less feasible, especially if few destinations are within reasonable walking-distance. In regards to safety, the two most salient safety concerns of older adults are worrying about accidents and the fear of crime. When a car accident happens, older people are more likely to suffer from injury, compared to younger people. There is higher probability for the elderly to fall in public transit vehicles due to losing balance. Moreover, the fear of being an easy victim of crime exists, whether older people are driving, taking public transit, or walking. Lastly, controllability or the sense of control is essential to well-being. For instance, evidence shows that the loss of driving, due to either decreased physical competence or the loss of driver's license, is associated with the sense of dependency and dissatisfaction. The understanding of these qualities of elderly mobility and accessibility is significantly related to an understanding of the built environment on local and regional scales.

1.10. Dissertation Structure

These demographic and environmental issues raise several questions. How has the morphology of age-restricted neighborhoods evolved? Do age-restricted neighborhoods' community settings and/or physical designs influence their older residents' local behavior? In urban areas, what role does neighborhood design play in older adults' walking behavior? Are the dual goals of promoting older adults' walking levels and improving the safety of the walking environment compatible?

This dissertation seeks to examine these questions. It investigates suburban baby boomers with a particular emphasis on the age-restricted neighborhood and behavioral differences its residents may display relative to residents in un-restricted neighborhoods. It also explores urban environments, focusing on a potential tradeoff between walkability and safety. Its aim is to offer better understanding of the role of neighborhood design and community settings in promoting active and safe aging, which is potentially applicable to neighborhood planning for older adults. Ultimately, the dissertation aspires to provide insight into sustainable neighborhood design and planning for the aging population.

The dissertation consists of three self-contained yet interrelated essays.[3] Following this introduction, the first essay (Chapter 2) examines age-restricted neighborhoods' physical characteristics, identifying their key design features that may influence suburban baby boomers' travel behavior. It also compares walkability levels and several types of local behavior – such as, walking/biking and social engagement – of 55-to-64-year-old baby boomers between five representative age-restricted neighborhoods and five nearby un-restricted neighborhoods in Massachusetts. This exploratory analysis gives a brief overview of the evolution of age-restricted neighborhoods' morphology and its potential influence on baby boomers' travel behavior.

The second essay (Chapter 3) seeks to reveal causal influences of age-restricted neighborhoods

[3] Parts of this dissertation rely on survey data generated by Professors Eran Ben-Joseph and P. Christopher Zegras, as well as Frank Hebbert as part of a New England University Transportation Center research grant in 2008.

on suburban baby boomers' behavior. The analysis attempts to distinguish community (for example, social network) effects from physical (for example, street network) influences. Age-restricted status proxies the community influence, offering age-exclusive social structure and aging-friendly services. Key physical characteristics, identified in Chapter 2, are objectively measured, using a Geographic Information System (GIS). Behavioral models estimate these community and physical effects on recreational walk/bike and social activity trip-making, which play a role in maintaining baby boomers' physical and mental health.

While the first and second essays study suburban baby boomers and age-restricted neighborhoods, the third essay (Chapter 4) investigates their counterparts in urban neighborhoods, with a primary focus on the interactions between urban form and safety that affect urban baby boomers' walking behavior. The analysis uses behavioral and socio-demographic data collected from baby boomers living in urban neighborhoods in Boston, Brookline, Cambridge, and Somerville. A variety of urban form elements and traffic accident levels of those neighborhoods are again objectively measured with GIS. Behavioral models investigate the impact of these physical characteristics and safety levels on baby boomers' walking behavior.

Chapter 5 concludes by summarizing the influence of neighborhood design as identified in the analyses. It reviews the conceptual framework and findings of the suburban and urban neighborhood analyses. By comparing urban and suburban environments and travel behavior, it also attempt to identify differences between how urban and suburban neighborhood characteristics affect their residents' local behavior. It synthesizes findings from the intra-suburban, intra-urban, and inter-urban-suburban analyses, discussing major planning, policy, and research implications. It ends with an outline of future research.

Chapters of this dissertation have been published in journals and conference proceedings under joint authorships with the dissertation advisors, Professors Eran Ben-Joseph and P. Christopher Zegras. Parts of Chapter 3 were published in the paper, "By Community or Design? Age-Restricted Neighborhoods, Physical Design and Baby Boomers' Local Travel Behavior in Suburban Boston, USA" in the journal, *Urban Studies*. Parts of Chapter 4, "Safely Active Mobility for Urban Baby Boomers: The Role of Neighborhood Design," were presented at the International Conference on Emerging Issues in Safe and Sustainable Mobility for Older Persons. Washington D.C.

Chapter 2

Emerging Suburban Form for Baby Boomers: A Morphological Analysis of Age-Restricted Neighborhoods in Suburban Boston

2.1. Introduction

Age-restricted neighborhoods, providing age-targeted physical design and social services, have significant implications for baby boomers' active aging. Over several decades, age-restricted neighborhoods have become an increasingly prevalent form of residential development across the US. Despite the apparent increase in age-restricted neighborhoods, little research has examined their physical characteristics and design with regard to their influence on the travel behavior, public health, and well-being of older adults. This chapter investigates the morphology of age-restricted neighborhoods in the Boston metropolitan area. Specifically, it aims to understand how physical characteristics of age-restricted neighborhoods have evolved and whether older adults living in age-restricted neighborhoods have notably different travel behaviors (e.g., increased/decreased auto use) from their counterparts living in "ordinary" suburban settings.

To examine these issues, the physical characteristics of age-restricted neighborhoods are compared to those of nearby un-restricted neighborhoods, using typomorphology, which classifies morphological elements, such as buildings, open spaces, and parcels, to understand urban form. Then, exploratory analysis of travel behavior survey data is conducted, comparing various types of travel behavior of baby boomers in age-restricted and un-restricted neighborhoods. The study focuses on the "leading-edge" boomers (aged 55 to 64), the first wave of baby boomers, transitioning into retirement. This age cohort is a key demographic group not only eligible for purchasing housing in age-restricted neighborhoods, but also targeted by developers and marketers of this type of development. This research aims to better inform relevant community design and neighborhood development approaches so as to ensure that current and future communities can adequately meet the needs of aging baby boomers (e.g., physical and social active-living possibilities and subsequent health benefits) and the broader community (e.g., safety, private vehicle use, and congestion reduction).

2.2. Background and Research Questions

2.2.1. Age-Restricted Neighborhoods

The growth of age-restricted neighborhoods is the result of interactions between market demand and responses, mediated by legal interventions. In the US, the age-restricted neighborhood originated with Benjamin Schleifer's Youngtown, Arizona, built in 1954 in suburban Phoenix and designed to provide a place to age in a socially active, affordable, and child-free setting (Blechman, 2008). In the early years of age-restricted neighborhoods, neither the federal government nor local municipalities provided any legal support for age discrimination against younger people. Today, the US allows age-restricted development for older adults to legally restrict residents to people over a certain age, which is one of the few permissible types of housing discrimination in the country.

The federal Fair Housing Act (FHA) of 1968 has banned discrimination in housing based on race, color, religion, and national origin. The amendments of FHA in 1974 and 1988 included the prohibition of discrimination based on sex, handicap, and "family status," which includes households with a child or children under the age of 18 or a pregnant woman. FHA prohibits the refusal of sale, rental, and financing of housing to a person in these categories. Therefore, the early FHA did not legally allow age-restricted neighborhoods that exclude children. However, advocates for older adults argued the need for an exemption that would approve senior-only environments to satisfy older adults' special needs (Heudorfer, 2005). As a result, FHA allowed an exemption from the family status for "housing for older persons" under three conditions:

1. The HUD Secretary has determined that it is specifically designed for and occupied by elderly persons under a Federal, State or local government program;
2. It is occupied solely by persons who are 62 years of age or older; or
3. It houses at least one person who are 55 years of age or older in at least 80 percent of the occupied units, and adhere to a policy that demonstrates intent to house persons who are 55 or older.

Although this exemption provided legal grounds for age-restricted neighborhoods, there was confusion about the age qualification, as well as facilities and service provision. In particular, the definition of 80 % and the disposition of individual houses after 55+ residents pass away were problematic for developers (Dawson, 2010). Also, housing had to provide significant facilities and services for older adults. However, the qualification of "significant facilities and services" was unclear. To clarify the FHA's exemption and simplify the process for qualifying for eligibility, Congress passed the Housing for Older Persons Act of 1995 (HOPA), dropping the "facilities" requirement and elaborating minimal criteria for eligibility of age-restricted developments. HOPA amended the requirements for the exemption as follows:

1. At least 80 percent of occupied units must be occupied by at least one person 55 years of age or older;
2. The housing facility or community must publish and adhere to policies and procedures that demonstrate intent and operation of the community for people above 55 years of age; and
3. The community must comply with HUD rules for verification of occupancy.

With this legislation, HOPA provides a support for developers to expand the age-restricted neighborhood market. The Department of Housing and Urban Development (HUD) was charged to implement and regulate HOPA as of 1995. HUD qualifies each development's age-restricted status, guiding developers to explicitly state that occupancy is restricted to households with at least one 55+ resident. Developers generally advertise this type of development as "active adult" or "active adult lifestyle" communities, specifically targeting relatively healthy baby boomers who are looking for an environment that can support their active lifestyle.

2.2.2. Socio-Demographics of Age-Restricted Neighborhoods

Until the 1990s, age-restricted neighborhoods were primarily developed in Sun Belt cities, based on an assumption that the retired older adults would prefer to relocate to warmer climates. The Southwest and Florida are still the largest markets of age-restricted neighborhoods: Arizona is the strongest market (38% age-restricted neighborhood units), followed by Florida (21%) and California (16%). However, as market research in the 1990s identified older adults' desire and preference for staying close to family members and friends in retirement, other markets in northern areas emerged in places where older adults live now, such as Atlanta, Chicago, New York, and other major cities (Suchman, 2001).

The trajectory of the demand for age-restricted neighborhoods shows an upward trend, despite the relatively small current market share of neighborhoods that exclusively serve older adults. Among 55+ home owners as of 2005 in the US, 3.3% of households were in age-restricted neighborhoods and 23.7% were in neighborhoods that, although not explicitly age-restricted, were mostly occupied by people aged 55 and older. The share of age-restricted neighborhoods in the housing market is likely to grow, as the share of older adults is expected to grow (Emrath & Liu, 2007). The age-restricted developments are mostly located in suburban areas: over 70% of age-restricted neighborhoods are built in suburbs, reflecting baby boomers' preference for a suburban lifestyle and the inclination of developers who are familiar with conventional suburban housing development (Emrath & Liu, 2007).[4]

[4] Overall older adult (and age-restricted) household locations in the US: 23 percent (14 percent) central cities; 50 percent (71 percent) suburbs; and 27 percent (15 percent) outside metro areas (derived from Emrath and Liu, 2007, Tables 1 and 2).

The proliferation of the age-restricted neighborhood is driven by three socio-demographic factors: First, senior housing is generally growing in the US. While still accounting for a relatively small share of total housing activity, demand for housing in age-qualified or age-dominated communities has been growing and should continue to grow. The 55+ population is expected to increase from 76.6 million (24.5 % of the US population) in 2010 to 85.6 million (26.3 %) in 2014 (Emrath & Liu, 2007). Second, the baby boom generation tends to be wealthier and healthier, relative to the previous generation of older adults. Therefore, baby boomers are generally capable of purchasing housing, and according to a major age-restricted neighborhood developer's survey: 42% of them plan to buy a new house after their retirement (Del Webb, 2010). Third, the needs, tastes, and lifestyles of an aging population are changing. Older adults tend to prefer or require housing that is more affordable, smaller, easier to maintain, and more accessible on a single level than their existing home. However, homogenous suburban detached single-family housing makes it difficult for older adults to age in place or to find suitable alternatives satisfying their needs and tastes (Heudorfer, 2005). Developers have attempted to design age-restricted neighborhoods to reflect these changing needs and tastes of older adults, which seems to contribute to the growth of the market by appealing to older adults who are searching for new homes.

2.2.3. Research Precedents: Morphological Analysis of Neighborhoods

The research employs typomorphological analysis to trace the evolution of age-restricted neighborhoods' physical and spatial structures. The unique features of this approach include: (1) defining types as a combination of built structures and open spaces within the contexts of sites; (2) including lands and subdivisions (lots or parcels) as fundamental elements of types that connect small (building) scale elements to larger (city) scale structures; and (3) classifying urban forms by time of production, use, and modification, rather than as static structures (Moudon, 1994).

More specifically, M.R.G. Conzen (1980), a geographer and town planner, focused on describing, analyzing, and explaining the factors and processes of building urban form. His method includes the *town* *plan* (two-dimensional representation of a town's physical elements, such as streets, plots, and buildings), the *building fabric* (patterns of buildings and related open spaces), and the *land and building utilization* (land use). Conzen further developed the concept of *compositeness* (the variations in the forms, uses, and configurations) of the town plan, which consists of *plan units* (the unique combinations of street, lot, building size, and shape) that emerge from different socio-economic settings and periods of buildings. The layers of the *plan units* constitute the *stratification* of the town plan, which implies the organization of the different units.

Researchers in urban planning have applied typomorphology to their studies of urban form in order to understand the processes and forces that have shaped the built environment over time. Moudon (1986) studied the morphology of sixty blocks of Alamo Square in San Francisco with a goal of explaining the design and building traditions of the residential area through the development process since the mid-nineteenth century. By analyzing the physical forms and uses of land subdivisions, buildings, blocks, and open spaces, her study revealed how residential environments could constrain or support everyday activities.

Southworth and Owen (1993) studied the evolving form of suburbs in the San Francisco Bay area on three scales: the community, the neighborhood, and the street. They categorized the community land use patterns (e.g., strip commercial/continuous residential and contained commercial/fragmented residential), street patterns (e.g., the gridiron, fragmented parallels, and loops and lollipops), lot and building patterns, and urban fringe form and patterns (e.g., fragmentation, diffusion, and separation). Their analysis identified the increasingly self-contained and single-use development patterns that have eroded the integrity of the public street framework and connections between neighborhoods.

Southworth (1997) evaluated the design of neotraditional communities, which are characterized by higher density, greater mix of uses, and provision of transit services, relative to typical suburban developments. He compared diverse morphological elements, including built form, land use, public open spaces, street design, and pedestrian access, of two prototype neotraditional communities (Kentlands and

Laguna West) to those of conventional late-twentieth-century suburbs.

Using the analytical framework of Southworth, Lee and Ahn (2003) compared the morphologies of Kentlands and Radburn that epitomize the Garden City and New Urbanism, respectively. New Urbanists support residential developments with high density, mixed uses, and better street connectivity, criticizing the fact that the elements of conventional suburbs – e.g., low density, cul-de-sacs, and superblocks – are inherited from Radburn. However, Lee and Ahn revealed that the Garden City and New Urbanism pursued the same goal of walkable residential environments, and that their prescriptions, as applied to Radburn and Kentlands, share common morphological elements.

2.2.4. Neighborhood's Morphology and Travel

Despite the increasing popularity of age-restricted neighborhoods, little is known about their physical environments or residents' travel and social activity patterns. Few published analyses have focused specifically on the morphology of age-restricted neighborhoods and their residents' travel behavior. In order to identify age-restricted neighborhoods' particular planning and design practices that could be adapted in non-restricted developments, the present chapter seeks to answer the following two questions:

- How have morphologies of age-restricted neighborhoods emerged and what factors have influenced their evolution?
- Do differences in residents' travel and social behavior exist between age-restricted and non-restricted neighborhoods?

The morphology of age-restricted neighborhoods tends to differ from the typical urban form of un-restricted suburban neighborhoods. Age-restricted neighborhoods generally include age-targeted design elements (e.g., golf courses, community centers, walking paths, accessible design) so as to meet baby boomers' residential needs, namely, housing and lots that requires low maintenance, provides more amenities, and offers affordably low prices for aging in place. These age-restricted neighborhoods have been enabled via several zoning mechanisms and promoted by incentives. Zoning mechanisms for age-restricted neighborhoods include rezoning of specific sites, senior housing districts, planned unit developments, and overlay districts. In Massachusetts, the state's affordable housing zoning law, Chapter 40B, has also contributed to the increase of age-restricted neighborhoods by providing an additional permitting pipeline (Heudorfer, 2005).

Local governments often encourage developers to build age-restricted neighborhoods by providing incentives. The age-restricted bylaws typically allow construction at a greater – often much greater – density than other types of development. Often other requirements (for example, lot size, dimensional requirements, parking, and open space) are also relaxed or waived. These incentives enable diversification of age-restricted neighborhood designs, for example, by the mix of housing types (attached and detached houses) and housing layout free from land subdivision regulations. Hence, the age-targeted design approach and other legal and socio-economic factors are likely to generate hybrid urban forms by transforming typical suburban neighborhoods' physical elements that are no longer suitable for baby boomers. Also, age-restricted neighborhoods offer well-organized social support through peer groups or social programs for baby boomers. Therefore, the hypothesis is that, under the confluence of physical design and social support of age-restricted neighborhoods, residents in this type of community maintain more active and social activity patterns, by creating social networks, social cohesion, and a greater perception of safety (Ahrentzen, 2010).

2.3. Empirical Settings and Methods

2.3.1. Study Area

The Phoenix Metropolitan Area

To trace how the morphology of age-restricted neighborhoods has evolved, the study compares such developments in the Boston metropolitan area to those in their birthplace, Phoenix, Arizona. The Phoenix metropolitan area encompasses two counties with 4.19 million persons in 2010.[5] Arizona is one of the most popular destinations for aging retirees and empty nesters, mostly due to its dry and hot climate and natural environments. The share of 55+ persons in Arizona is 25 percent, slightly higher than the national share (24 percent).[6] Absorbing this demand for retirement housing, Arizona is the second largest market offering age-restricted neighborhoods in the US (Suchman, 2001).

The Boston Metropolitan Area

The greater Boston Metropolitan Area had about 4.68 million persons in 2010, across five counties.[7] As one of the oldest cities in the US, Boston's inner core contains typical elements of older Northeastern cities: fairly dense residential development, urban rail and commuter rail services, and a strong central business district. With already a higher share (26 percent) of older persons 55+,[8] Massachusetts is expected to experience a greater than 50 percent increase in residents over the age of 55, almost 715,000 persons, during the period 2000 to 2020 (Heudorfer, 2005). These demographic trends, combined with local land use policies and fiscal considerations, have created a mini age-restricted development "boom" in Massachusetts. A recent study identified more than 150 age-restricted neighborhoods completed or under construction, as well as another 172 age-restricted neighborhoods in the proposal or permitting process (Heudorfer, 2005).

2.3.2. Methods

Neighborhood Selection

To examine morphological and behavioral implications of age-restricted neighborhoods, five age-restricted neighborhoods are selected from a list of 47 age-restricted developments in suburban Boston.

[5] U.S. Census Bureau 2010. State & County QuickFacts.
[6] The shares are calculated from Census 2010 State & County QuickFacts, Arizona.
[7] U.S. Census Bureau 2010. State & County QuickFacts.
[8] The shares are calculated from Census 2010 State & County QuickFacts, Massachusetts.

The 47 age-restricted neighborhoods are classified into five categories, based on their morphological elements, including street patterns, housing types, and open spaces. From each of the five categories, five representative age-restricted neighborhoods are identified. Therefore, the selected neighborhoods epitomize physical forms frequently used for age-restricted developments in Boston suburbs. The five age-restricted neighborhoods are located in Chelmsford, Hudson, Shrewsbury, Norton, and Plymouth. Five matched un-restricted neighborhoods near the five age-restricted neighborhoods are selected to compare neighborhood characteristics of the two types (Figure 2-1b).

Sun City in Arizona, which is the earliest age-restricted development, is also selected so as to compare physical characteristics of age-restricted neighborhoods in different locations (Arizona and Massachusetts) and time periods (from Sun City in 1960 to present) (Figure 2-1a). Sun City epitomizes a fairly homogeneous physical form of the age-restricted neighborhood in Arizona. To provide a matched comparison, an area of typical subdivisions near each age-restricted neighborhood in the same town is chosen (Figure 2-2). In each neighborhood, a typical 40 hectares (100 acres) area is selected for more detailed morphological analysis.

Morphological Analysis

This exploration aims to reveal how the idea of age-targeted design has changed typical suburban neighborhood development patterns and has been adapted to different socio-economic settings. The analysis is conducted at two scales:

- ***Meso Scale***: The locations of age-restricted neighborhoods are identified, in order to assess neighborhoods' accessibility to city centers, regional destinations, and transportation systems.

- ***Neighborhood Scale***: This study compares the neighborhood-level morphologies between age-restricted and nearby un-restricted neighborhoods, so as to evaluate the local-level influence of the age-restricted neighborhoods' physical characteristics. The analysis, using diagrams and maps, classifies neighborhoods, by taking into account a variety of physical elements, such as street patterns, street density, intersection density, open spaces (including private yards and public space), the number of blocks, the number of loops and cul-de-sacs, dwelling density, and building types.

Among the neighborhood-scale measures, the street patterns of neighborhoods are categorized into three types (Figure 2-3): Lollipops on a Stick (linear), Fragmented or Warped Parallel (grid) and Master-planned (loop). This categorization is based on the premise that people prefer non-duplicative, circular routes for their walking. Master-planned (loops) and Fragmented or Warped Parallel (grid) types provide multiple route possibilities while Lollipops on a Stick (linear) street networks reduce such possibilities (Southworth & Owens, 1993).

Using these street types and age-restriction status, several neighborhood characteristics are compared by measuring dwelling density, road density, and Walk Score™,[9] which is a public access walkability index that assigns numerical walkability scores (from 0 to 100) to individual addresses. The Walk Scores can be classified into five categories: Walker's Paradise (Daily errands do not require a car); Very Walkable (Most errands can be accomplished on foot); Somewhat Walkable (Some amenities within walking distance); Car-Dependent (A few amenities within walking distance); and Car-Dependent (Almost all errands require a car). Walk Score is a composite measure that incorporates (1) walking routes and actual walking distances to amenities; (2) intersection density and block length that represent street connectivity; and (3) scores for individual amenity categories. The morphological analysis aims to reveal substantive differences in neighborhood characteristics among these neighborhood types.

Household Travel Behavior Survey

[9] http://www.walkscore.com/

A mail-back household survey collected socioeconomic and behavioral information of residents aged 55–64 living in Boston suburbs. Chapter 3 includes a detailed description of this mail-back household survey. Mailed packages included a travel survey for retrospective trip counts of nine types of travel over the past week, including commuting by automobile and public transportation, recreational trips, non-motorized trips such as walking and biking, and social trips within neighborhoods and to other areas. From the final data set with 1859 individuals in Boston suburbs, travel behavior data of 364 individuals from the 10 selected neighborhoods were extracted. Using these data, an exploratory analysis compared the baby boomers' travel behavior in age-restricted and un-restricted neighborhoods, as well as in neighborhoods with the three street patterns.

2.4. FINDINGS

2.4.1. Morphological Analysis

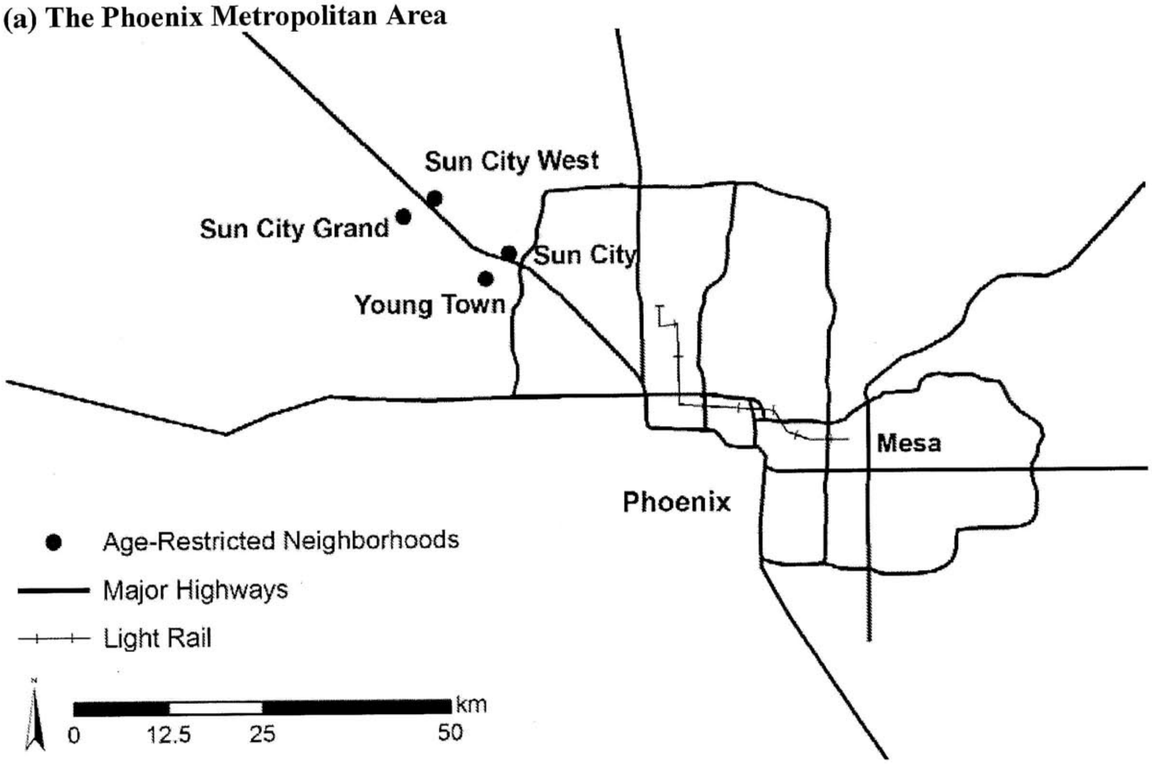
The metropolitan scale analysis (Figure 2-1) shows that the age-restricted neighborhoods are primarily a suburban phenomenon, generally having better accessibility by automobiles than by public transit. In Phoenix, age-restricted neighborhoods tend to be located near the periphery of the metropolitan area. The two salient concentrations of age-restricted neighborhoods are in the Northwest Valley and in the eastern area of Mesa (Figure 2-1a).The first age-restricted neighborhoods, Young Town and the Sun City trio – Sun City, Sun City West, and Sun City Grand – are located in the Northwest Valley. In Mesa, there are approximately 10 major and numerous other age-restricted neighborhoods. These are typically highly accessible from the highway network, yet less so from Phoenix' light rail system: for example, the distance from Sun City to a highway intersection is much closer than the distance to the closest light rail station (Table 2-1). Age-restricted neighborhoods in Massachusetts are also located in suburban areas, having fairly nearby access to several major highways and commuter rail access (Figure 2-1b and Table 2-1). However, none of the neighborhoods have light or commuter rail stations within a walkable distance.

Overall, age-restricted neighborhoods tend to be located closer to highways, but proximity to public transportation systems does not appear to be a crucial locational factor.

Figure 2-2 shows age-restricted neighborhoods and their adjacent typical suburban fabrics. In Phoenix, the morphological fabrics (dwelling density and road density in Table 2-1) of age-restricted and un-restricted neighborhoods are quite similar, since these age-restricted neighborhoods followed a typical suburban development model that divides lands into individual parcels. Yet Sun City includes golf courses and walking trails for older adults' recreation and other amenities. In Massachusetts, the morphology of age-restricted neighborhoods is distinguishable from un-restricted neighborhoods. Most age-restricted neighborhoods do not parcelize their lands and include attached housing, providing public open space instead of individual front and back yards. Consequently, the design of age-restricted neighborhoods is much more diverse than nearby neighborhoods based on typical suburban subdivisions. The dwelling density of age-restricted neighborhoods seems to be higher than un-restricted neighborhoods. However, overall dwelling density, including open spaces and roads, of age-restricted neighborhoods, is not discernibly higher than surrounding neighborhoods (Figure 2-4). This is a result of clustering the units while providing ample open space at the periphery.

Figure 2-1. Transportation Network and Selected Age-Restricted Neighborhoods

(a) The Phoenix Metropolitan Area



(b) The Boston Metropolitan Area

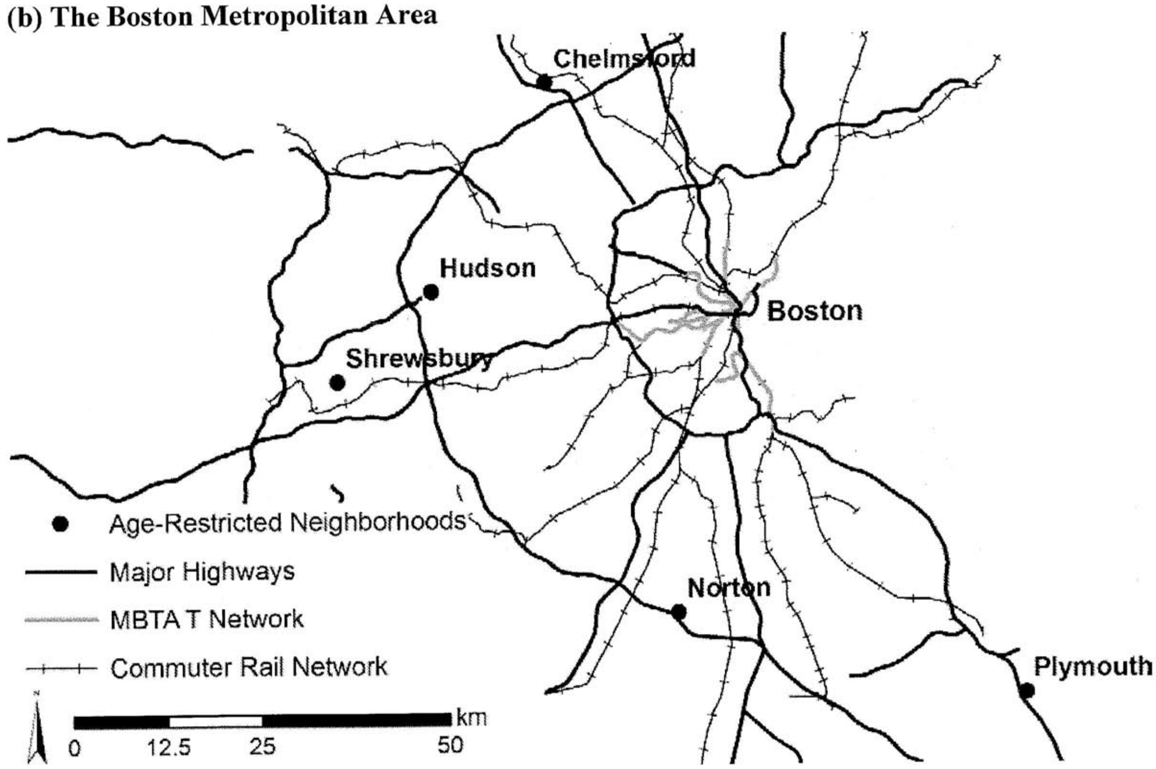
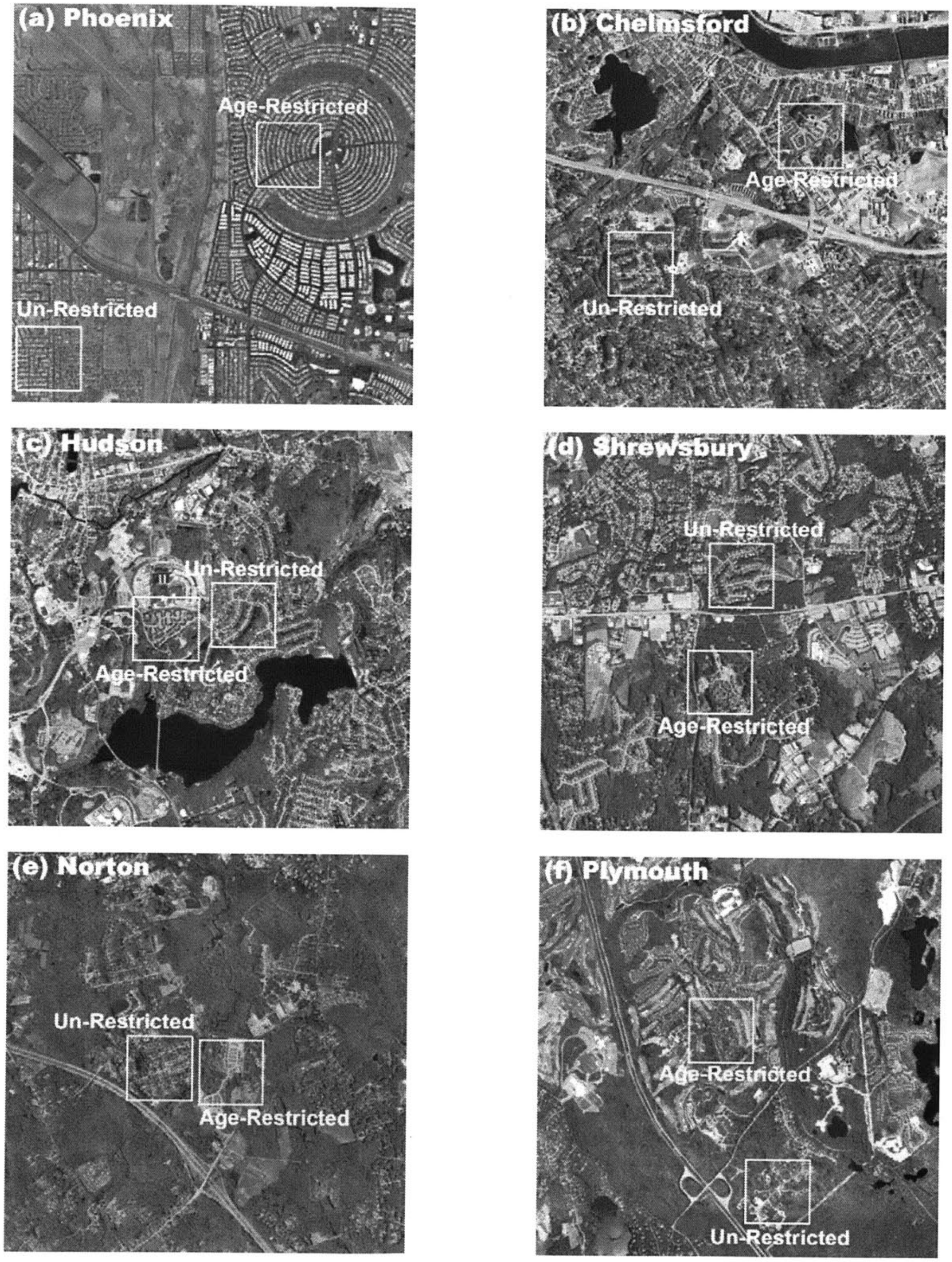


Figure 2-2. Selected Age-Restricted Neighborhoods and Nearby Un-Restricted Neighborhoods



Note: Surrounding areas (3,953 acre; 1,600 ha; 4 by 4 km) of the neighborhoods are presented.
White boxes indicate representative fabrics of neighborhoods (100 acre; 40 ha; 636 by 636 meter)

Table 2-1. Comparative Analysis of Neighborhood Characteristics and Walkability

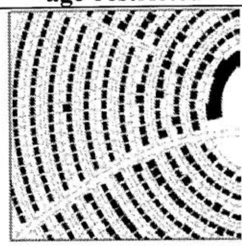
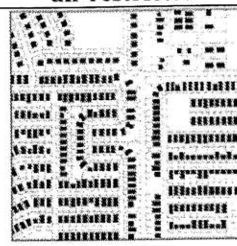
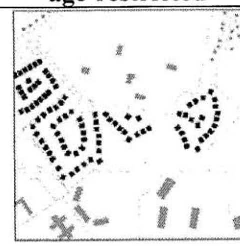
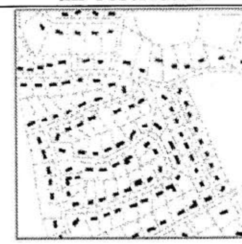
	Sun City		Chelmsford	
	age-restricted	**un-restricted**	**age-restricted**	**un-restricted**
Building Footprints and Parcels [a]				
Neighborhood Characteristics				
Housing Type	Mixed	Detached Single Family	Detached Single Family	Detached Single Family
Year Built [b]	1960	2000	1998	1960
Area (ha) [c]	3,780	40.4	40.5	40.4
Dwellings [c]	27,731	347	71	116
Trail [c]	Yes	No	No	No
Urban Form				
Dwelling Density (units / km^2)	738	859	283	283
Road Density (km / km^2)	11.9	10.6	7.8	8.2
Services and Transport				
Distance to Highway (km) [d]	4.2	5.0	0.9	1.8
Distance to Commuter (km) [d]	19.6	20.5	4.5	6.3
Available Destinations [e]	19	13	19	17
Walkability Score [f]	16	21	12	9
The Number of Trips per Week [g]: Mean (S.D.)				
Drive to work			2.6 (2.5)	4.1 (2.1)
Go to work on public transit			0.0 (0.2)	0.0 (0.0)
Transport someone (pickup, drop off)			0.9 (1.2)	1.3 (1.7)
Go shopping			2.7 (1.6)	2.4 (1.3)
Go out for recreation			2.8 (2.0)	1.8 (1.5)
Walk or cycle in a neighborhood.			1.9 (2.5)	2.1 (2.2)
Travel to another area for exercise			0.9 (1.7)	1.3 (2.1)
Visit neighbors			0.7 (1.6)	0.4 (0.9)
Visit a friend in other neighborhoods			1.1 (1.4)	0.6 (1.1)

Table 2-1. (continued)

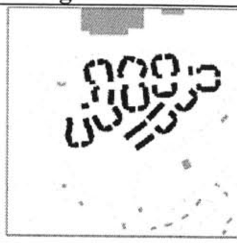
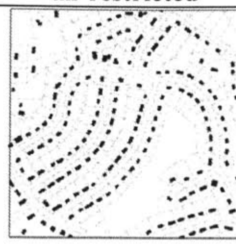
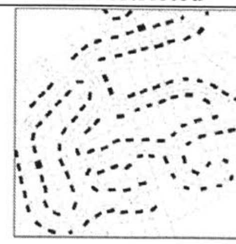
	Hudson		Shrewsbury	
	age-restricted	**un-restricted**	**age-restricted**	**un-restricted**
Building Footprints and Parcels [a]				
Neighborhood Characteristics				
Housing Type	Attached Single Family	Detached Single Family	Attached Single Family	Detached Single Family
Year Built [b]	2003	1965	2005	1995
Area (ha) [c]	15.9	40.4	17.9	40.4
Dwellings [c]	150	187	90	116
Trail [c]	Yes	No	No	No
Urban Form				
Dwelling Density (units / km^2)	366	456	220	283
Road Density (km / km^2)	7.2	9.4	7.0	7.2
Services and Transport				
Distance to Highway (km) [d]	3.3	3.9	1.0	1.2
Distance to Commuter (km) [d]	12.3	11.6	3.3	4.0
Available Destinations [e]	21	21	14	18
Walkability Score [f]	35	8	15	24
The Number of Trips per Week [g]: Mean (S.D.)				
Drive to work	2.4 (2.9)	2.9 (2.3)	3.0 (2.9)	3.2 (2.8)
Go to work on public transit	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Transport someone (pickup, drop off)	1.2 (1.2)	1.0 (1.5)	0.7 (1.3)	0.5 (1.0)
Go shopping	2.8 (1.4)	2.6 (1.2)	2.5 (1.5)	2.2 (1.3)
Go out for recreation	2.5 (1.1)	2.1 (1.9)	3.1 (1.8)	1.8 (1.5)
Walk or cycle in a neighborhood.	2.6 (2.1)	1.9 (2.2)	2.6 (2.9)	1.9 (2.5)
Travel to another area for exercise	1.1 (1.9)	1.0 (1.6)	1.0 (1.5)	0.4 (1.2)
Visit neighbors	1.1 (1.2)	0.8 (1.0)	0.4 (0.7)	0.4 (0.9)
Visit a friend in other neighborhoods	0.9 (1.0)	0.8 (1.0)	0.6 (0.8)	0.7 (0.9)

Table 2-1. (continued)

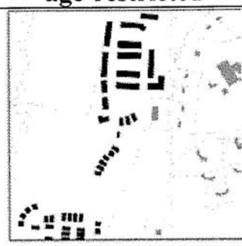
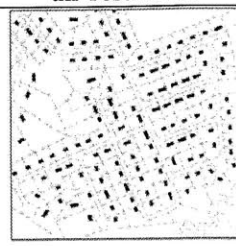
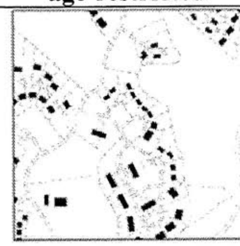
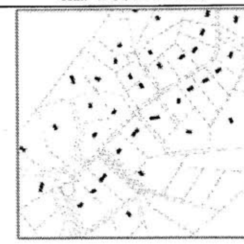
	Norton		Plymouth	
	age-restricted	un-restricted	age-restricted	un-restricted
Building Footprints and Parcels [a]				
Neighborhood Characteristics				
Housing Type	Attached Single Family	Detached Single Family	Attached Single Family	Detached Single Family
Year Built [b]	2005	1974	1997	2000
Area (ha) [c]	21.5	40.4	1,215	40.4
Dwellings [c]	156	130	2,983	38
Trail [c]	Yes	No	Yes	No
Urban Form				
Dwelling Density (units / km^2)	271	317	161	88
Road Density (km / km^2)	8.6	9.0	12.1	2.8
Services and Transport				
Distance to Highway (km) [d]	4.32	3.86	1.51	1.03
Distance to Commuter (km) [d]	4.86	5.89	12.71	14.26
Available Destinations [e]	5	8	9	8
Walkability Score [f]	20	6	11	6
The Number of Trips per Week [g]: Mean (S.D.)				
Drive to work	1.9 (3.4)	3.1 (2.5)	2.0 (2.6)	2.7 (2.5)
Go to work on public transit	0.6 (1.8)	0.2 (0.9)	0.1 (1.0)	0.1 (0.8)
Transport someone (pickup, drop off)	0.4 (1.1)	0.6 (1.2)	0.8 (1.3)	1.4 (1.9)
Go shopping	3.3 (2.8)	2.2 (1.4)	2.6 (1.4)	2.1 (1.2)
Go out for recreation	2.6 (2.0)	2.1 (1.7)	3.0 (1.8)	2.5 (1.7)
Walk or cycle in a neighborhood.	4.3 (2.9)	2.3 (2.3)	2.6 (2.4)	2.6 (2.4)
Travel to another area for exercise	2.9 (2.6)	0.8 (1.7)	1.6 (2.1)	1.1 (2.1)
Visit neighbors	0.9 (1.5)	0.7 (1.3)	1.1 (1.3)	0.9 (1.5)
Visit a friend in other neighborhoods	0.8 (0.7)	0.8 (1.0)	0.8 (1.1)	1.0 (1.6)

Table 2-1. (continued)

Note:

a: The units (100 acre; 40.4 ha) of the diagrams correspond to the white boxes in Figure 2-2. Un-restricted developments, included in the units for age-restricted neighborhoods, are shaded in grey and excluded from the analysis.

b: For age-restricted neighborhoods, the built year indicates the completion of the first phase of a development . For un-restricted neighborhoods, the median built year is calculated based on the information from http://www.zillow.com/.

c: For age-restricted neighborhoods, the characteristics are drawn within the neighborhoods' own boundaries. For un-restricted neighborhoods, the numbers are calculated within the 40.4 ha boundaries of the figures.

d: Straight line distances from the center of the 40.4 ha boundaries to the closest highway intersections and commuter rail stations

e: The number of destinations are counted within 1.6 km (1 mi) radius; Source: http://www.walkscore.com/

f: Street Smart Walk Score takes into account (1) walking routes and actual walking distances to amenities; (2) road connectivity metrics such as intersection density and block length; and (3) scores for individual amenity categories. A detailed description of Walk Score computation is available at http://www2.walkscore.com/pdf/WalkScoreMethodology.pdf

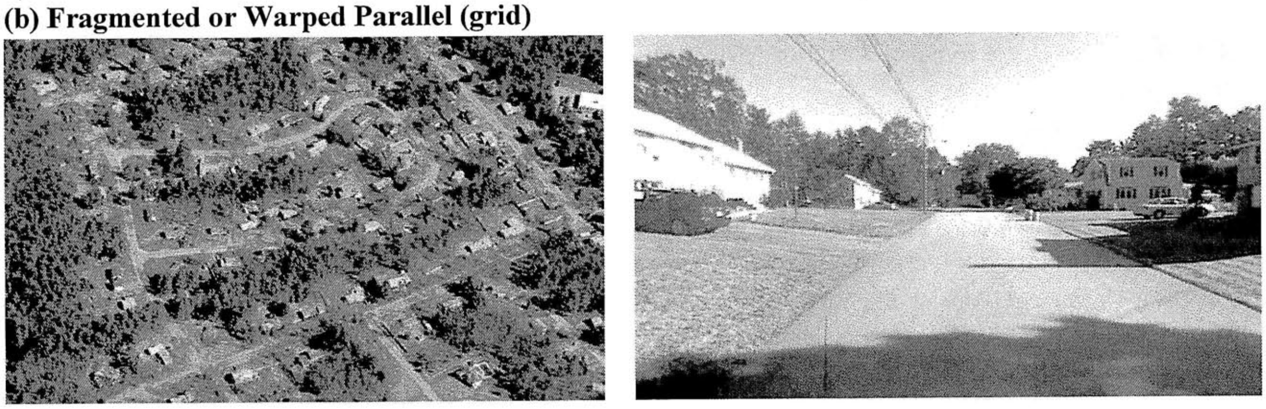
Walk Score Criteria
90–100: Walker's Paradise (Daily errands do not require a car);
70–89: Very Walkable (Most errands can be accomplished on foot);
50–69: Somewhat Walkable (Some amenities within walking distance);
25–49: Car-Dependent (A few amenities within walking distance);
0–24: Car-Dependent (Almost all errands require a car)

g: The descriptive statistics for each neighborhood are drawn from a mail-back household survey.

Figure 2-3. Aerial Views and Street Views of Three Street Types

(a) Lollipops on a Stick (linear)

(b) Fragmented or Warped Parallel (grid)



(c) Master-planned (loop)

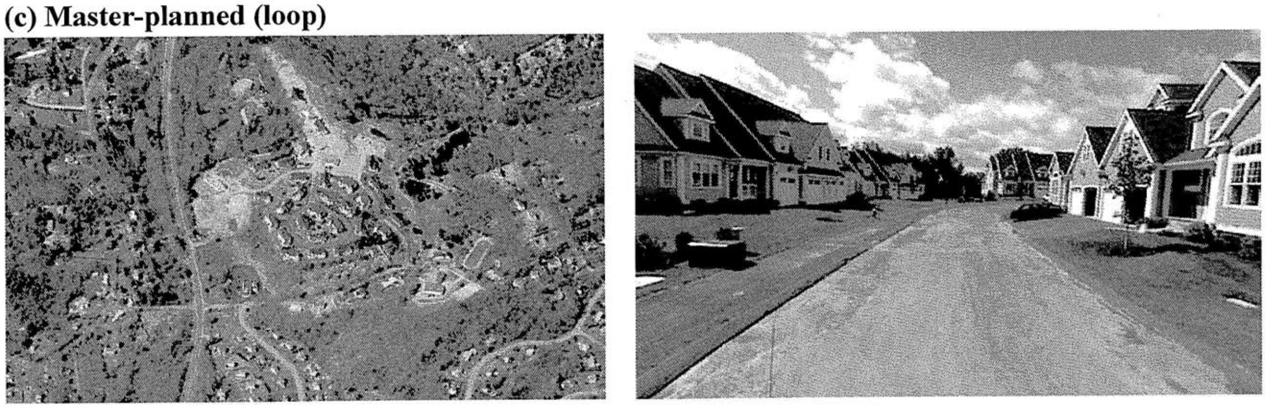
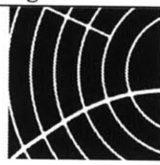
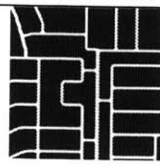
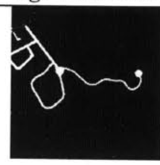
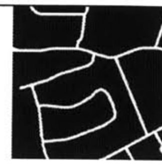
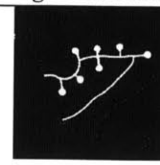
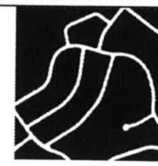
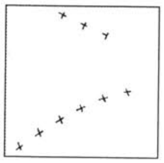
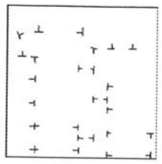
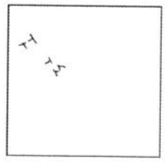
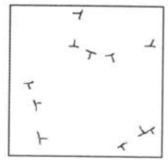
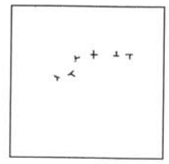
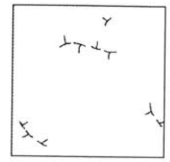
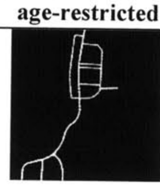
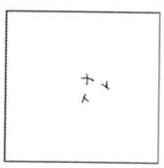
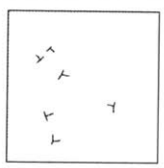
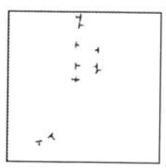
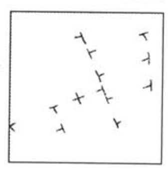
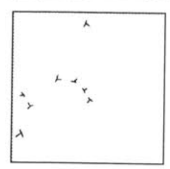
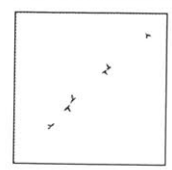


Table 2-2. Comparative Analysis of Neighborhood Street Patterns

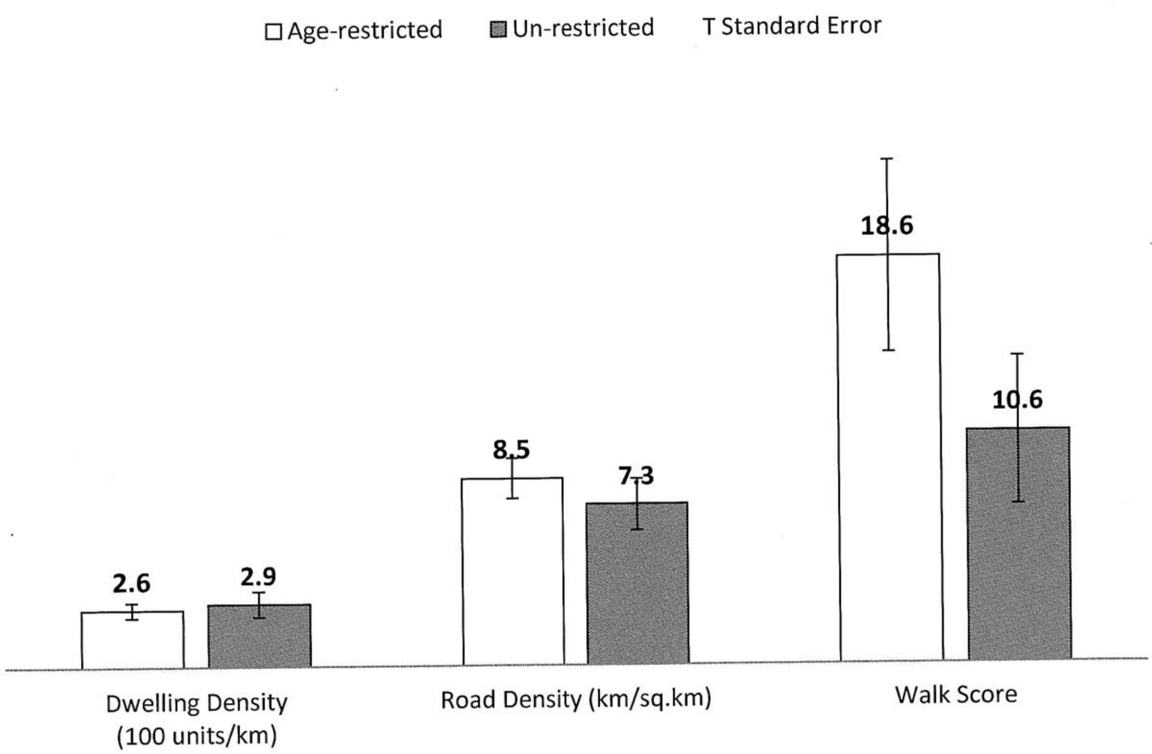
	Sun City		Chelmsford		Hudson	
	age-restricted	**un-restricted**	**age-restricted**	**un-restricted**	**age-restricted**	**un-restricted**
Street Patterns [a]						
Intersections						
Street Pattern	Wrapped Parallel (Grid)	Fragmented Parallel (Grid)	Master Planned (Loop)	Wrapped Parallel (Grid)	Master Planned (Loop)	Wrapped Parallel (Grid)
Lineal Meters of Streets	1349.7	1405.5	397.8 (659.5)	905.8	237.7 (738.1)	898.6
# of blocks	18	25	4	11	2	10
# of intersections	9	26	5	11	6	10
# of cul-de-sacs	0	0	2	2	7	1

	Shrewsbury		Norton		Plymouth	
	age-restricted	**un-restricted**	**age-restricted**	**un-restricted**	**age-restricted**	**un-restricted**
Street Patterns [a]						
Intersections [b]						
Street Pattern	Master Planned (Loop)	Wrapped Parallel (Grid)	Master Planned (Loop)	Fragmented Parallel (Grid)	Master Planned (Loop)	Lollipops on a Stick (Linear)
Lineal Meters of Streets [c]	391.4 (744.4)	758.6	527.5(756.9)	910.6	638.5	488.5
# of blocks	5	5	9	8	7	4
# of intersections	3	6	10	13	8	6
# of cul-de-sacs	1	2	0	6	5	4

a: The table refers to the 100 acre (40.4 ha) units of analysis in the diagrams, which correspond to those in Table 1. Un-restricted streets, around age-restricted neighborhoods, are shaded in grey and excluded in the analysis.
b: Intersections are defined as junctions of multiple streets.
c: Lineal meters in parenthesis include both age-restricted and un-restricted streets.

The comparative analysis of street patterns (Table 2-2) identifies no significant differences in street connectivity between age-restricted and un-restricted neighborhoods. Road density (lineal meters / 100 acres) and intersection density (the number of intersections / 100 acres) of age-restricted neighborhoods are similar to those of un-restricted neighborhoods. Figure 2-4 also shows that the average road density in age-restricted neighborhoods is slightly higher than in un-restricted neighborhoods, but the difference is small.

Figure 2-4. Neighborhood Characteristics by Age-restriction Status



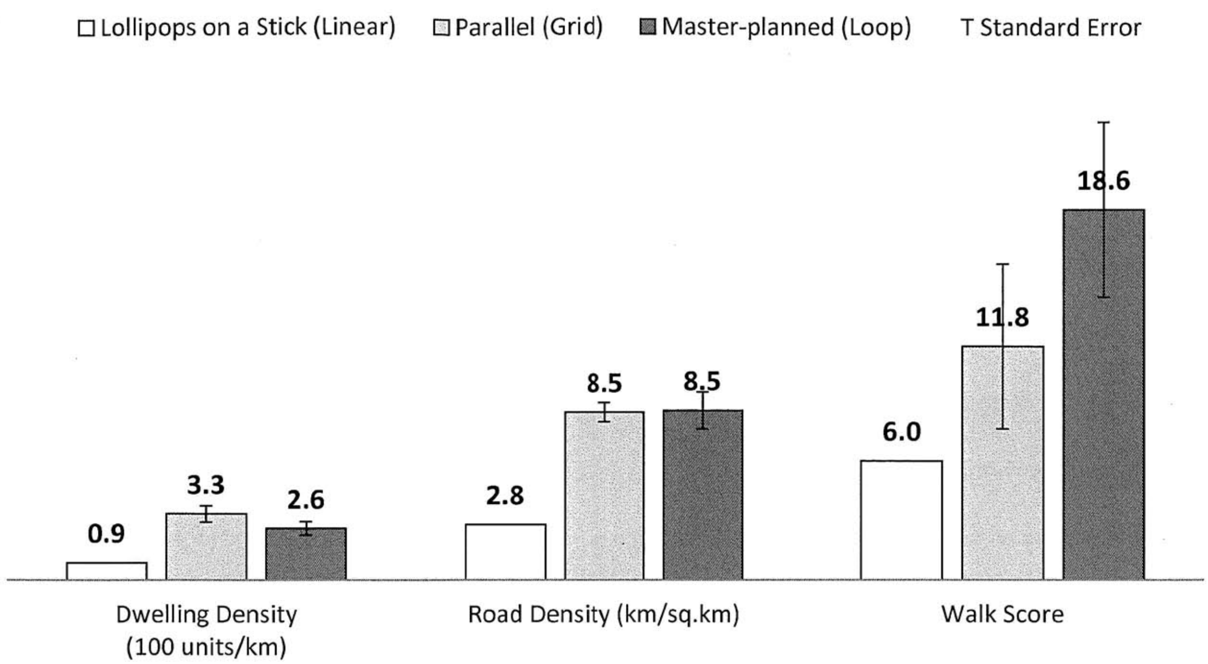
Note: Walk Score Criteria
90–100: Walker's Paradise (Daily errands do not require a car);
70–89: Very Walkable (Most errands can be accomplished on foot);
50–69: Somewhat Walkable (Some amenities within walking distance);
25–49: Car-Dependent (A few amenities within walking distance);
0–24: Car-Dependent (Almost all errands require a car)

The suburban locations and neighborhood characteristics of age-restricted neighborhoods are associated with a low level of walkability. While age-restricted developments tend to provide more amenities within neighborhoods than typical nearby developments, the number of available destinations is not sufficient to achieve higher levels of walkability: these neighborhoods' Walk Scores (Table 2-1) are generally below 25, indicating that these neighborhoods are car-dependent environments where almost all errands require a car. Hudson's age-restricted neighborhood is the most walkable (Walk Score 30), yet still has few amenities within walking distance. Figure 2-4 shows that Walk Scores in age-restricted neighborhoods tend to be higher than those in un-restricted neighborhoods. However, the average Walk Score in age-restricted neighborhoods is still below 25.

The comparison of neighborhood characteristics among the three types of street pattern implies that the morphological differences between suburban neighborhoods are not significantly large (Table 2-2). The Lollipops on a Stick (linear) type tends to maximize privacy, accompanied by limited route choice and access points. The large blocks and cul-de-sacs are likely to reduce pedestrian access to destinations. The Fragmented or Warped Parallels (grid) type tend to offer more access points and better interconnection than the Lollipops on a Stick (Southworth & Owens, 1993). Age-restricted neighborhoods in the sample are Master-planned (loop) type, which provides un-disrupted internal circulation with few access points. Hence, this type suggests a self-contained neighborhood.

The analysis found higher dwelling density, road density, and Walk Scores of grid and loop types than linear types (Figure 2-5). There is no discernible difference in dwelling density and road density between the grid and loop types. But the linear type has significantly lower dwelling and road densities than the grid and loop types. Among the three types, the Walk Score of the loop type is the highest, followed by the grid type, and the linear type's Walk Score is the lowest. However, Walk Scores of all the three types remain highly automobile-dependent.

Figure 2-5. Neighborhood Characteristics by Street Patterns



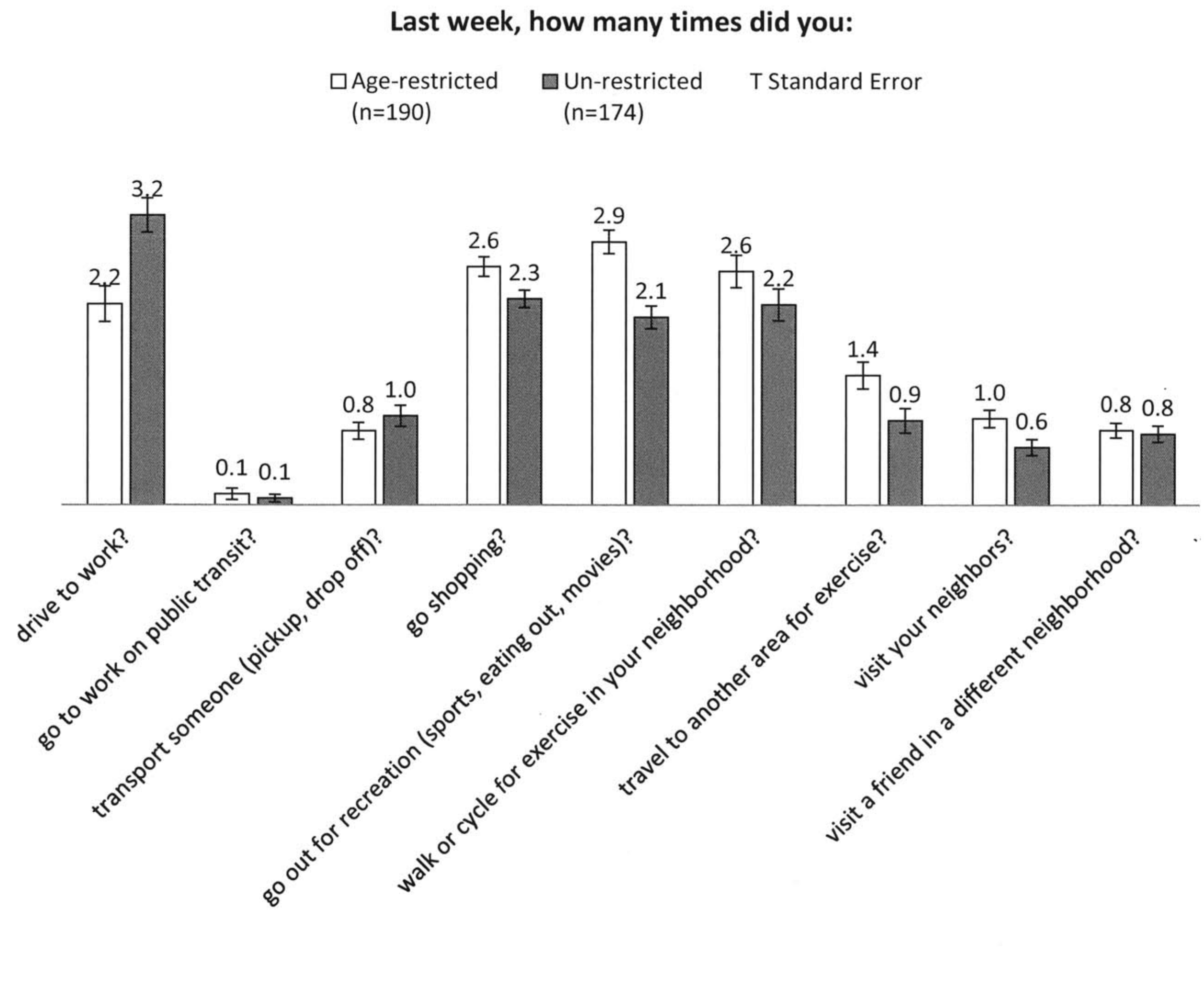
Note: Walk Score Criteria
90–100: Walker's Paradise (Daily errands do not require a car);
70–89: Very Walkable (Most errands can be accomplished on foot);
50–69: Somewhat Walkable (Some amenities within walking distance);
25–49: Car-Dependent (A few amenities within walking distance);
0–24: Car-Dependent (Almost all errands require a car)

2.4.2. Household Travel Behavior Analysis

Table 2-1 includes the average trip counts among residents in each neighborhood and Figure 2-6 compares the average trip frequencies between age-restricted and un-restricted neighborhoods. Comparing travel behavior of the two neighborhood types, the residents in age-restricted neighborhoods tend to drive for commuting more often, relative to those in un-restricted areas. The frequency of transporting someone is higher in un-restricted neighborhoods. The residents in age-restricted neighborhoods tend to be more active in making non-work trips – including shopping and going out for recreation, as well as walking, biking, or traveling to another area for exercise – compared to those in un-restricted developments.

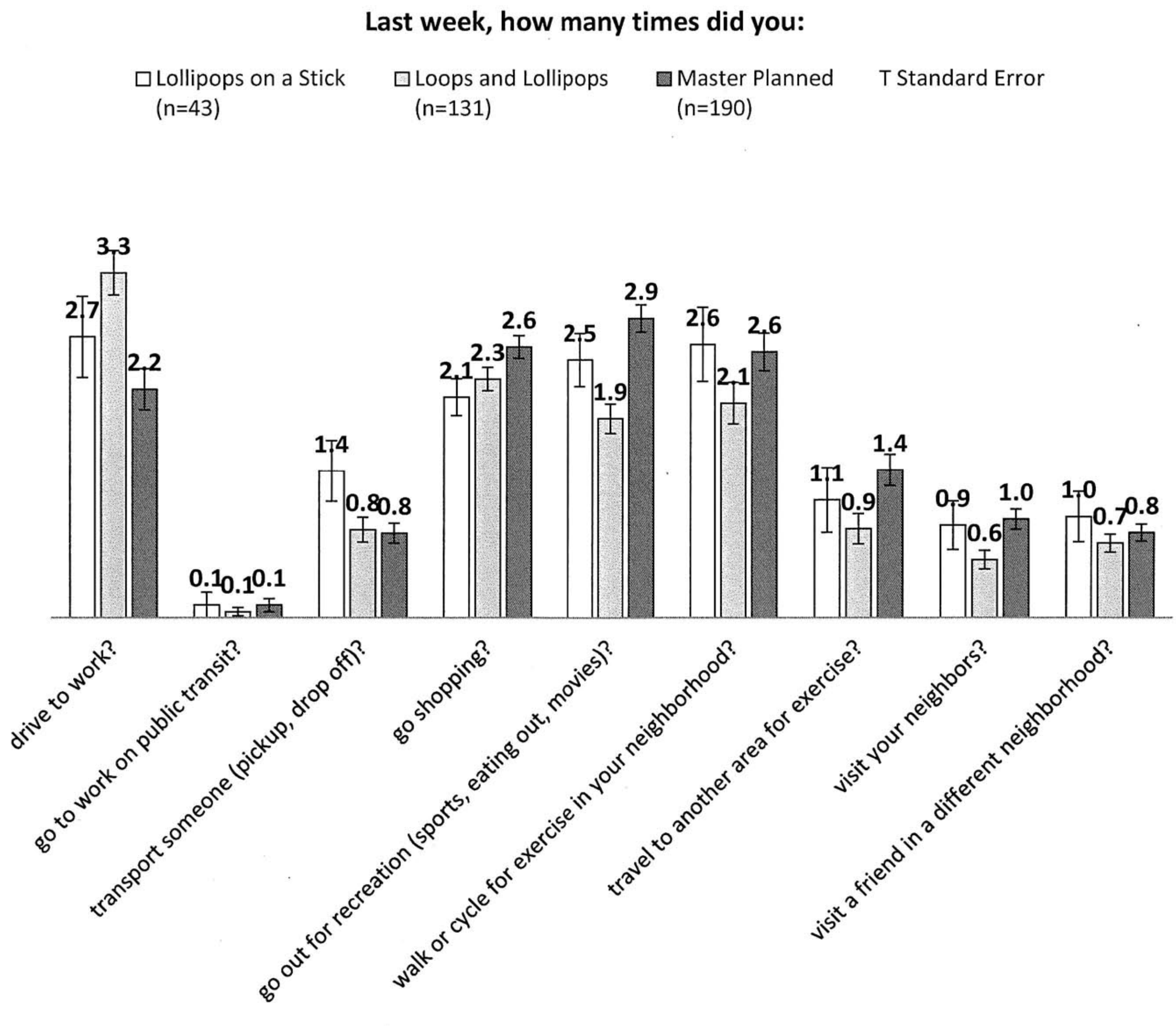
The social activity level (visiting neighbors) within the neighborhoods is also slightly higher in age-restricted neighborhoods. In addition, this exploratory analysis does not control for the personal characteristics of residents, including employment status and their travel attitudes and residential preferences, nor does it distinguish the influence of physical characteristics from social services and other community features of age-restricted neighborhoods. Therefore, although slightly more active and less automobile-dependent travel behavior in age-restricted neighborhoods is identified, these differences cannot be conclusively attributed to the morphology of age-restricted neighborhoods.

Figure 2-6. Baby Boomers' Travel Behavior by Age-restriction Status



The comparison of travel behavior in Figure 2-7 suggests that the differences in travel patterns by the street patterns are even smaller than the difference between age-restricted and un-restricted types. Residents in Master-planned type neighborhoods tend to use their cars less, as well as go out for recreation and walk or bike more, than those in other types. However, the relatively large standard error indicates these differences are not large. This result implies that the variations in suburban street patterns are not adequate to induce behavioral changes of baby boomers.

Figure 2-7. Baby Boomers' Travel Behavior by Street Patterns



2.5. Conclusion

The morphological analysis revealed both the possibilities and limitations of age-restricted neighborhood design. Age-restricted neighborhoods are generally master-planned developments, meaning that overall design elements of neighborhoods are coherently coordinated. Moreover, age-restricted neighborhoods often have certain regulations or requirements relaxed or waived. These requirements, particularly excessive right-of-way width, turning radii, minimum lot size, and setbacks, often prevent unconventional neighborhood design that promotes denser and walkable developments (Ben-Joseph, 2005). The more relaxed requirements associated with age-restricted neighborhoods allow the introduction of diverse forms of attached single-family housing, different site configurations, and land ownership that is communal rather than private. Most age-restricted neighborhoods also provide community centers and gyms, as well as outdoor recreational facilities such as golf courses and trails.

While these design strategies are expected to promote physical and social activities, the limited connectivity of age-restricted neighborhoods' street patterns and lack of potential nearby destinations lead to low levels of walkability, similar to typical suburban neighborhoods. Age-restricted neighborhoods' design shows only small differences in their residents' travel behavior as compared to un-restricted neighborhoods.

The exploratory nature of this study does not allow conclusive confirmation that the observed slightly more active and less automobile-dependent lifestyle in age-restricted neighborhoods is due to age-targeted design or social services. The analysis includes only 10 neighborhoods in Massachusetts, although these neighborhoods represent typical age-restricted developments in the Boston metro area. It also uses a relatively small number of observations from these neighborhoods (one-fifth of total observations in the survey data set) and other potential covariates that may influence the results. Hence, in order to examine the causal influence of neighborhood and community features, the next chapter comprehensively analyzes baby boomers' behavioral and socio-economic characteristics, as well as physical characteristics of age-restricted neighborhoods that are included in the survey data. Further research may look at developers' decision-making process of neighborhood design and location. This study would allow us to understand why most age-restricted developments tend to be located isolated from potential destinations and service, as well as how developers could choose better designs and locations for their developments to improve their residents' mobility and neighborhoods' accessibility.

Chapter 3

By Community or Design?
The Influence of Age-Restricted Neighborhoods and Physical Design on Baby Boomers' Local Travel Behavior in Suburban Boston

3.1. Introduction

This chapter explores the causal relationship between age-restricted neighborhoods and baby boomers' local travel habits. Ostensibly designed for older adult lifestyle preferences, age-restricted neighborhoods might influence physical and/or social activity among residents, leading to healthier lifestyles. Examining this possibility, the primary focus of the study is on recreational walk/bike and local social trip-making among "leading-edge" baby boomers (age 55–64 during data collection in 2008): comparing age-restricted neighborhoods in suburban Boston with nearby un-restricted neighborhoods; and assessing the effects of neighborhoods' physical characteristics. That implies two sources of behavioral effects: those arising from social (and other unobserved) characteristics of age-restricted "community" and those resulting from particular physical "neighborhood" attributes.

Neighborhood versus Community

The concept of neighborhood may be the finest unit of urban design and planning. Although building level or building cluster level analyses are often conducted, neighborhoods are more often design and analyzed by urbanists due to their implications arising from the interactions between physical and social aspects. Many researchers and designers have assessed existing neighborhoods and proposed desirable neighborhood designs, so as to improve residents' quality of life. The concept of neighborhood has been defined in various ways and referred to by other terms such as community and town. Comparing "neighborhood" and "community" can clarify the meaning and implications of these terms.

The key distinction between the two terms is the place-based nature of neighborhoods, while communities can exist beyond place-based boundaries. Therefore, a "community" is a more general term that describes units of human society, whereas a "neighborhood" stresses the physical aspects of human society or place. Urban designers and geographers have focused on the physical aspect of neighborhoods.

Physical planers, such as Clarence Stein, have been more interested in physical aspects than social aspects of neighborhoods. They have paid primary attention to the physical elements, such as land use, density, street pattern, boundaries, and the amount of open space. In contrast, social planners have stressed social dimensions in terms of shared activities and experience, the results of social groupings, and common values and loyalties; they believed that the physical aspects of neighborhoods are irrelevant to social dimension and therefore less important and useful (Hester 1975).

Other planners have attempted to embrace both the physical and social aspects of neighborhoods. Milton Kotler (2005) proposed a definition of neighborhood: "a political settlement of small territory and familiar association, whose absolute property is its capacity for deliberate democracy." He included the political dimension of neighborhoods in the light of increasing demand of residents to control their neighborhoods. Kevin Lynch (1984) defined a neighborhood as "a place where permanent residents are in face-to-face contact, and are on intimate terms with each other because they live next to each other." He argued that spatial proximity can develop a sense of community and thus, residents will support each other. In accordance with Kotler's discussion of neighborhoods' political aspect, Lynch regarded a neighborhood as a grass roots unit of city politics, because residents will argue for the local interests.

From this point onward: "neighborhood" means a geographically bounded unit in which residents share proximity and the circumstances that come with it (Chaskin, 1995, p. l); and "community" means the broader network of interpersonal relationships providing sociability, support, information, a sense of belonging, and social identity (Wellman, 2005, p. 53). A community might coincide with a neighborhood;

age-restricted neighborhoods aim, in part, to create community. Assisted living and congregated care facilities are excluded to control for the potentially different travel capabilities of individuals with assisted-living needs and, subsequently, the possible influences of neighborhood designs specific to such residents. The age-restricted status serves as a proxy for community in this study. In this chapter, being "social" and making social trips refer to individual characteristics and activities; "community" refers to the broader network of interpersonal relationships, as already defined and as distinguished based on the restricted/un-restricted neighborhood of residence.

Local Behavior of Interest

Finally, this chapter examines two types of individuals' local activities. The first is local recreational walking and bicycle use – hereafter, "recreational non-motorized transport" (NMT) – because increasing physical activity helps healthy aging and local NMT can satisfy recommendations for older adults' regular moderate physical activity (DiPietro, 2001; Eyler et al., 2003). The second is local social engagement– hereafter, "social trips" – since being socially disengaged may lessen physical and mental health and residential neighborhoods can maintain and increase social networks via proximity and shared physical settings, enhancing residents' well-being (Kweon et al., 1998; Yang and Stark, 2010). Separating these trip types adds important nuance to the analysis, as neighborhoods and communities might vary in their impacts on different travel behaviors and individuals may choose particular settings to satisfy certain behavioral preferences; the settings, in turn, may then influence other behaviors.

3.2. Background and Research Questions

3.2.1. Theory of Behavior, Psychology, and the Built Environment

Researchers in the fields of transportation, psychology, and urban planning have proposed theoretical frameworks that attempt to explain the relationships among the built environment, latent psychological constructs, and human behavior.

Ecological Model of Aging

In the field of gerontology, the relationship between older adults and environments has attracted significant attention. Kurt Lewin (1951) proposed the notion of life-space, which includes not only personal and physical space but also psychological space, in which the person and environment interact with each other. Powell Lawton (1973) described these relationships with an ecological equation: Behavior = f (*P, E, P**E*), where the *P**E* term denotes the interaction between person (*P*) and environment (*E*). Lawton's model used two constructs: "personal competence" and "environmental press." First, personal competence is a personal characteristic, conceived as the expected maximum performance; its manifestations include biological health, sensory perceptual capacity, motor skills, cognitive capacity, and ego strength. Second, environmental press represents the environmental influence on a person associated with personal needs or behavioral outcomes.

Key to Lawton's model is the docility hypothesis, in which high personal competence implies relative independence from the demand of environmental press while low personal competence is associated with a higher level of vulnerability to environmental press. Thus, people with lower personal competence are more sensitive to environmental influences. The natural process of aging reduces strength and endurance of physical, social, and economic capacity; thereby increasing environmental influences, such as spatial distance, on older adults' behavior (e.g., walking). Therefore, the built environment tends to exert a greater influence on older adults than on their younger counterparts. The built environment may also interact with other relevant environmental dimensions, including personal (family and friends), suprapersonal (age or racial composition in a neighborhood), and social environments (norms or values in a society).

Random Utility Model

In the field of transportation, one of the most coherent and rigorous theoretical frameworks is the random utility model, borrowed from microeconomic theory. This model assumes that travelers make rational decisions to maximize their utility by mostly minimizing travel time and costs (disutility), under given time and budget constraints. The utilities can be decomposed into the systematic utility, which is determined by the attributes of alternatives and the characteristics of decision makers, and the error term, which represents unknown factors (e.g., unobserved attributes and taste variations) (Ben-Akiva & Lerman, 1985; Crane, 1996; McFadden, 2001). This framework views travel as a derived demand, assuming that individuals travel in order to participate in activities at destinations. Therefore, the demand for travel is derived from the demand for activities. In this framework, the urban form measurements focus on factors that affect a traveler's choice: for example, street connectivity may influence travel distances and people may choose the shortest route in order to minimize travel costs (and therefore, maximize the utility).

Net Utility Model

More elaborate framework of random utility model is "net utility" model (Maat et al., 2005). By this theory, people choose to walk based on the expected utility of the trip (i.e., whether the system gets a user to a desired destination) and the relative (to other available modes) disutility of realizing the trip, which includes time and costs – all of which may vary by the users' socioeconomic and demographic characteristics. The time component of a trip also includes two elements: actual and perceived (subjective) times, with the latter influenced by comfort levels (e.g., amenities, safety, etc.). In this way, we can formally understand the role that the built and social environments might play in determining walking behavior. The built environment determines the relative location of potential destinations of interest; at the same time, street and path networks impact actual distances and times – by determining, for example, directness of routes and number of stops, crossings, and other interferences. These same networks' conditions and other elements of the built environment, such as density and diversity of different land uses, impact perceived times – by affecting, for example, the overall walking experience (Jiang et al., 2012).

Theory of Planned Behavior

The theory of planned behavior attempts to explain behavioral outcomes with psychological factors: *intention, perceived behavioral control, attitudes,* and *subjective norms* (Ajzen, 1991). *Intention* represents the level of an individual's inclination to behave, while *perceived behavioral control* denotes an individual's perception of her own ability to execute the behavior. *Attitude* represents the subjective evaluation of the behavior, whereas *subjective norms* correspond to the social pressure on an individual's decision to enact the behavior. The theory of planned behavior suggests that intention and perceived behavioral control influence the person's behavior and that intention is also predicted by perceived behavioral control, attitude, and subjective norms. Thus, an individual, who has a favorable attitude toward walking, feels confident to walk, and is encouraged to walk by other members in her society, is more likely to have a high intention to walk, and therefore make a decision to walk.

New Urbanism

In the field of urban design, New Urbanism promotes a vision of high-density, transit-oriented, and pedestrian-friendly developments as an alternative to leapfrogging urban sprawl. It has repackaged a variety of traditional, as well as contemporary, physical design ideas. Andres Duany and Elizabeth Plater-Zyberk are the most salient leaders of the New Urbanism movement. Their fundamental interest is to reshape suburban sprawl patterns to create compact and walkable places that can accommodate social interactions in neighborhoods. Duany and Plater-Zyberk (1994) insisted that an ideal neighborhood has a center and an edge; a quarter-mile span from center to edge (a five-minute walk, pedestrian-friendly, transit-oriented); a balanced mix of activities (good for the young, the elderly, and even those who drive); a fine network of interconnecting streets (multiple routes for pedestrians and traffic); and public spaces and civic buildings (representing community identity, fostering civic pride).

Peter Calthorpe is another leading New Urbanist who is a proponent of ecology, sustainability, new regionalism, and environmentalism. He insisted that there is a profound mismatch between the old suburban patterns and the post-industrial culture today. He proposed the Pedestrian Pocket, a post-industrial suburb, which is defined as a balanced, mixed-use area within a quarter-mile or five-minute walking radius of a transit station (Calthorpe, 1989). He further refined the Pedestrian Pocket and proposed the idea of transit-oriented development (TOD).

New Urbanism has been controversial. While resonating with many urban planners and designers, the New Urbanism approach has been heavily criticized for a variety of reasons, including its nostalgic design language, the quasi-urban density that resulted in fancier suburban developments, the lack of evidence for its capability of achieving mixed-race and mixed-income population, and the unproven causal relationship between a compact development and decreased automobile use. However, New Urbanism embraces a variety of compelling planning ideas; potentially, it may provide a substantive theoretical framework for the fields of physical planning and urban design.

3.2.2. Research Precedents

Scholars and others have long been interested in the travel behavior of the aging population (e.g., Wachs, 1979). In recent years, research has focused on a variety of topics including transportation's role in contributing to the well-being of older adults (Cvitkovich & Wister, 2001) and overall trip generation rates and travel distances of older adults (Schmöcker et al., 2005). Despite intensive research activity on the built environment-travel behavior relationship more generally, little of the research into the travel behavior of older adults has focused specifically on the role of the built environment. Some efforts do exist. For example, Bailey (2004) attempts to measure "elderly isolation," using the 2001 National Household Travel Survey (NHTS) data. He refers to people who stay at home on a given day, as related to the auto-dependency of older adults as influenced by urban form. In another study, using the 1999 Nationwide Personal Transportation Survey (NPTS), Rosenbloom and Waldorf (2001) include the effects of relative location (e.g., urban, suburban) on older adults' public transport and automobile choice. Unfortunately, these studies use few controls in their analysis and the crude location measure used provides few insights into neighborhood design and possible influences. Also, using the 1995 NPTS, Giuliano (2004) attempts to detect the effects of metropolitan-scale and neighborhood-scale (defined at census tract level) on elderly travel behavior. The neighborhood-scale variables are used to represent the built environment, including population density, employment density, a local services index, housing age as a proxy for land use dispersal, and share of homeowners as an income proxy. She finds few significant built environment effects on trip rates, except for a positive effect of local access. For trip distances (for non-work travel), she identifies significant effects of local access and density with differing effects detected between the "younger elderly" (65-74) and "older elderly" (75+).

The built environment and walking

Research consistently reveals associations between utilitarian walking and factors like proximity to destinations and public transit, street connectivity, mixed land use, and higher residential and job density (for example, Baran et al., 2008; Giles-Corti and Donovan, 2002; Giles-Corti et al., 2005; Huston et al., 2003; Lee and Moudon, 2006; Moudon et al., 2005; Saelens and Sallis, 2003). On the other hand, research focused on walking for recreation and exercise provides inconsistent results (Owen et al., 2004). Some studies show that sidewalks (Giles-Corti and Donovan, 2002), accessible destinations (Giles-Corti et al., 2005), hilliness (Lee and Moudon, 2006), and perception of attractiveness and safety (Alfonzo et al., 2008; Giles-Corti and Donovan, 2002) are associated with a higher level of recreational walking; other studies fail to reveal such correlations (Rodriguez et al., 2006; Saelens and Sallis, 2003).

Older adults' NMT use

King et al. (2003), examining older women (average age 74) in suburban and urban Pennsylvania, find a positive correlation between physical activities (pedometer measured) and convenient destinations and perceived walkability. Berke et al. (2007a) find neighborhood walkability in King County, Washington – measured via a spatial buffer of households and accounting for characteristics like dwelling unit density and proximity of grocery stores – to be inversely associated with depressive symptoms in older (65+) men (but not women). Berke et al. (2007b) also find a statistically significant relationship between the same walkability measure and frequency of older persons' (65+) walking for physical activity. Examining older people's (65+) travel behavior in northern California and controlling for attitudes, Cao et al. (2010) find that several neighborhood characteristics (for example, safety, distances) influence walk trip frequencies. Joseph and Zimring (2007) examine older adults' (age 77–83) path choice in three continuing care retirement neighborhoods in Atlanta, finding an association between: well-connected, destination-oriented paths and utilitarian walking; and longer, well-connected paths without steps and recreational walking. Finally, using multilevel regression, Nagel et al. (2008) find that high-volume streets and proximity to destinations positively influence total walking time among older adults (average age 74) in Portland (Oregon), while low-volume streets have a negative influence on total walking time. They find no association between the built environment and the odds of not walking, suggesting no neighborhood influence on sedentary older adults' walking behavior.

Neighborhood, community and older adults' social activities and/or wellbeing

Early US studies took a building-level perspective, often focusing on government-supported housing (Lawton et al., 1975). In Portland (Oregon), Chapman and Beaudet (1983) find older adults' (average age 78) interactions with neighbors to be highest in "good quality" neighborhoods, more distant from the city center, and with low shares of older people. Kweon et al. (1998) identify a positive association between time spent in common outdoor green spaces and measures of social integration and "sense of local community" among poor 64+ adults (average age 68) in Chicago's age-integrated public housing. Davison et al. (2001), comparing the friendship interaction of older residents of age-segregated, inner city public housing to counterparts of private housing elsewhere in Melbourne, find that the age-segregated setting is more likely to encourage people to interact with friends, relative to private housing. Yang and Stark (2010), using qualitative methods, find apparent behavioral influences of social features related to expectations of encounters and homogeneity of residents in assisted living facilities (stand-alone buildings). While they examine stand-alone buildings, not neighborhoods, some of their findings shed light on the apparent behavioral influences of social features related to expectation of encounters and the homogeneity of residents.

Finally, analyzing older adults' social interactions at a neighborhood level, Adams (1985) finds that physical proximity to friends is positively correlated with emotional closeness and frequency of interaction, using data from seventy white, non-married, female senior residents of Oak Park, a middle-class suburb of Chicago. However, this study takes into account only the proximity to friends without investigating other neighborhood characteristics, such as accessibility, destination, and amenities, which may affect social activities. In general, the gap of these studies is an understanding of the neighborhood-level effects on social engagement.

3.2.3. Age-Restricted Neighborhoods and Travel Behavior: Questions and Hypotheses

Little research has focused specifically on local travel behavior in age-restricted neighborhoods. As mentioned, Joseph and Zimring (2007) examined walk path choice in continuing care retirement neighborhoods. Flynn and Boenau (2007) estimated vehicular traffic counts for a suburban Virginia age-restricted neighborhood, finding trip rates comparable to those recommended for detached senior adult housing by the Institute of Transportation Engineers.

Several key features of age-restricted neighborhoods may influence local NMT use and social engagement. Specifically, relative to un-restricted neighborhoods, age-restricted neighborhoods may differ (Hebbert, 2008) by:

- *Demographics*: people of similar ages and interests, combined with physical disconnection from surrounding neighborhoods, may decrease the likelihood of encountering strangers;
- *Community*: programs, events, and clubhouses may increase residents' activity levels;
- *Suitability*: targeting the 55+ demographic and offering lifestyle choice amenities (e.g., golf courses, pools) may support more active living; and
- *Walkability*: trails and sidewalks, and little, if any, through-traffic may increase walking.

Age-restricted and un-restricted neighborhoods also share many similarities. The great majority (71 percent) of age-restricted neighborhoods in the US are suburban, even more suburban than overall locations of older adult households (Emrath and Liu, 2007). This implies limited connectivity to other neighborhoods, limited local retail, dispersed employment and other services, and limited public transport. Hence, the focus here is on local suburban context, where physical and community differences and, thus, potential behavioral effects may arise.

Do age-restricted neighborhoods influence local travel behavior? The social ecological model offers a theoretical frame for local travel behavior in age-restricted neighborhoods, emphasizing the reciprocal interactions between behavioral and environmental factors. Presuming that changes in community alter individual behaviors, the model focuses on relationships between environmental interventions and interpersonal, organizational, and other community factors (Sallis and Owen, 1996). Age-restricted neighborhoods may support baby boomers through peer groups, social programs, and higher perceived safety, among other things (for example, Ahrentzen, 2010). It is hypothesized that, after controlling for physical characteristics, age-restricted neighborhoods have more recreational NMT and social trips due to community effects.

Do neighborhood characteristics influence local travel behavior? As Maat et al. (2005) propose, a neighborhood's physical characteristics may influence travel behavior via effects on net utility – the utility of travel (for example, number, quality, distribution of destinations) less its disutility (actual and perceived travel costs). Consider, for example, prototypical street configurations: linear, loop and grid (see Figure 3-1). The latter two reduce non-duplicative routes (reducing travel's disutility) and, by clustering dwellings, increase opportunities to meet neighbors (increasing travel's utility). Thus, the hypothesis is that grid- and loop-type neighborhoods promote more recreational NMT and social trips, as do higher intersection density, neighborhood facilities (e.g., parks, golf courses), and proximity to other destinations, including public transport stops.

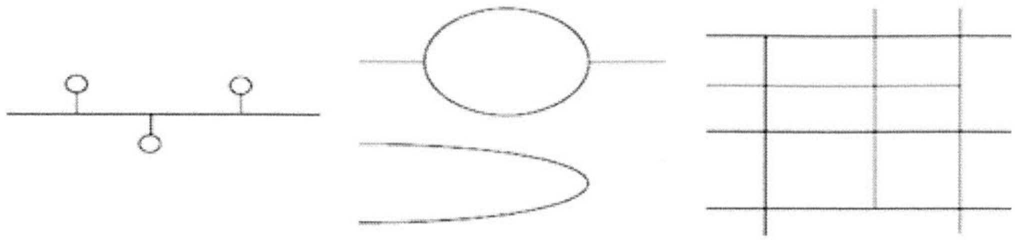
3.2.4. Analytical Challenges

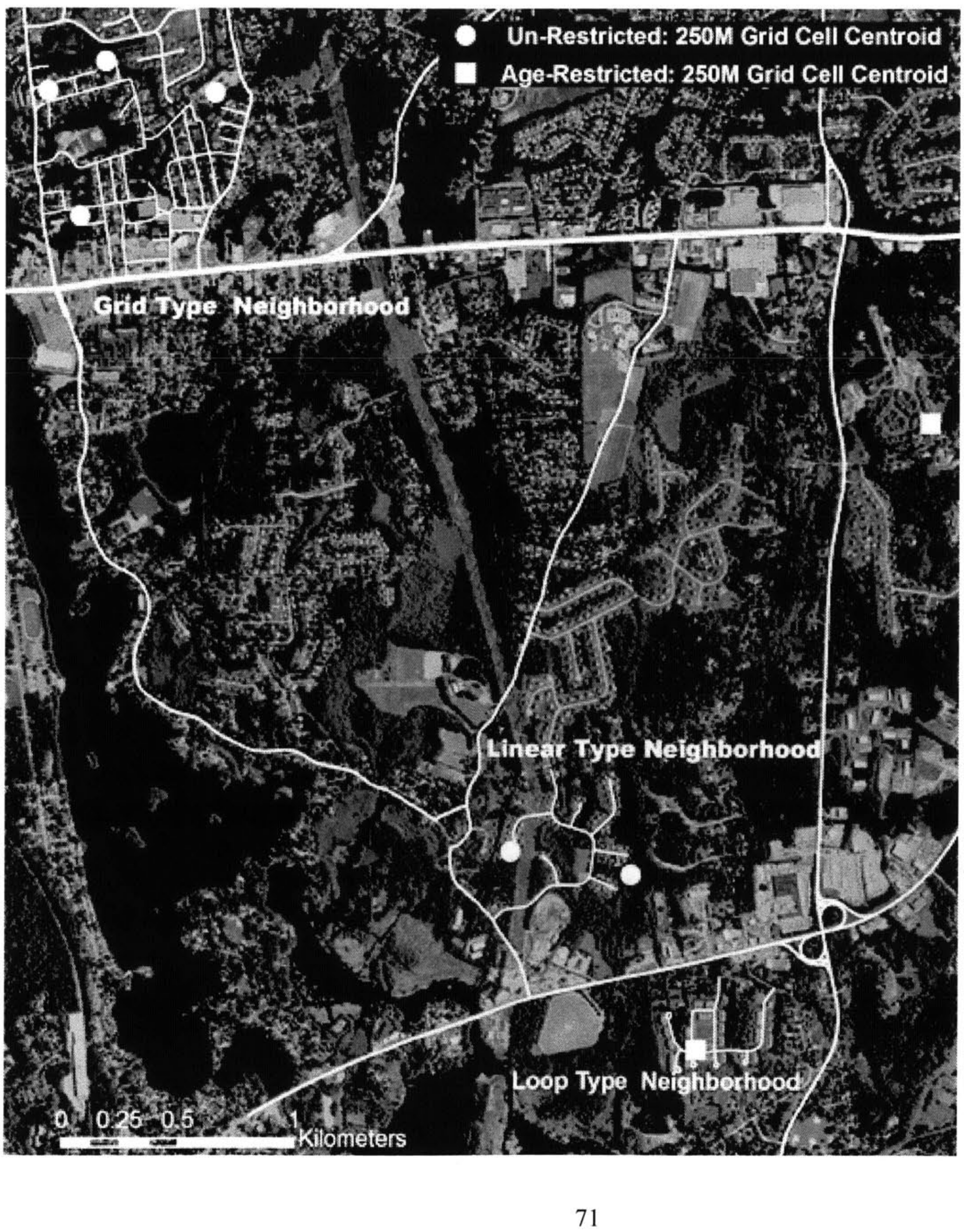
Causality

This analysis aims to reveal the "causal" influence of neighborhood design and community settings on baby boomers' local NMT and social behavior. Causality fundamentally answers the question of "why?" and, therefore, provides an explanation of the influence of urban form. In social science, a hypothesis is generally regarded as scientifically meaningful when it reveals causality (Singleton & Straits, 2005). From a policy perspective, causal reasoning is attractive, because it identifies causes of symptoms so as to help formulate policy strategies. When parties disagree on a certain policy, causal explanation through scientific procedures is compelling in that science is a set of agreed upon and objective procedures for achieving consensus (Rein & Winship, 1999).

Figure 3-1. Three Categories of Neighborhood Street Patterns, Descriptive Diagrams, and Prototypical Examples of the Categorization

(a) Linear Type **(b) Loop Type** **(c) Grid Type**





Causality is a relationship in which a change in one event (a cause) produces a change in another (an effect). Although the cause and effect relationship is essential for explanation and prediction, it is not straightforward to identify such a causal relationship. Causality is inferred from an observed association between events. David Hume (2007) argued that a causal relationship based on inference exists only in an observer's mind; it is impossible to logically and empirically prove the existence of causality. Interpretivists generally refuse to accept causal relationship between reduced variables; they argue that the relationships among aspects of the world are too complex. The only way to know the world is to understand it as a whole, depending on observers' idiosyncratic experiences and personalities (Morgan & Smircich, 1980). However, many researchers believe causality is the essence of scientific knowledge; it offers productive and useful intuitions, even if cannot be proven. Furthermore, social scientists generally regard the following three conditions as evidence of causality: association, direction of influence, and nonspuriousness (Singleton & Straits, 2005).

First, association is fundamental to causality; when changes in one variable are related to changes in another, the two variables can be regarded as being associated. In real world observations, associations are almost never perfect. Rather, a causal relationship sometimes implies "weak" associations. The reason for weak associations may be that multiple factors jointly and independently cause the same effect. Thus, observed weak associations may imply that a causal relationship exists, but not under the condition in which the weak association was observed. Therefore, researchers generally rely on statistical significance rather than strength of association, in order to detect meaningful association between variables.

The second condition for establishing causality, the direction of influence from cause to effect, is that a cause must precede its effect. Causality should allow only one direction of influence; changes in a cause should influence changes in effect, but the reversed influence should not exist. In the real world, this directionality is not easy to determine; for example, walkable neighborhoods may increase walking activities, but another possible interpretation is that people who prefer walking have chosen a walkable neighborhood or changed the neighborhood environment to be more walkable.

Lastly, even if a dependent variable and an independent variable are not inherently related, the relationship between the two happens to be observed when an extraneous variable is related to both of them. For instance, since population size is related to both the number of births and the amount of traffic, the association between the births and traffic may be observed, but an inherent relationship between the two is hardly plausible. Therefore, when there is no effect of an extraneous variable antecedent to dependent and independent variables, the relationship between the two is regarded as nonspurious. In addition, an extraneous variable, which is not antecedent but intervening between dependent and independent variables, does not generate spuriousness. Rather, it can enhance causal inference by contributing to identifying a "causal mechanism" (Singleton & Straits, 2005).

Even though causal effects are detected, we still do not know how our independent variables cause changes in our dependent variables. Some researchers argue that the central idea of causality is a "causal mechanism," which consists of a series of causal links between dependent and independent variables, because in order to understand why certain phenomena occur, we need to investigate how they are produced (King, Keohane, & Verba, 1994). Alexander George and Andrew Bennett (2005) discussed "process-tracing" as a method to identify the causal mechanism. They define causal mechanisms as "ultimately unobservable physical, social, or psychological processes through which agents with causal capacities operate, but only in specific contexts or conditions, to transfer energy, information, or matter to other entities," as opposed to statistical analyses, which omit all contextual and intervening variables except those measured and codified. Consequently, they defined process-tracing as "the method that attempts to identify the intervening causal process – the causal chain and causal mechanism – between an independent variable (or variables) and the outcome of the dependent variable."

True Experiment

In order to empirically reveal causal relationship, an ideal research strategy may be a true experimental design that divides observations into two groups: a treatment group with a manipulated independent variable and a control group without a manipulated independent variable. The key feature of the true experiment is random assignment that ensures each observation has an equal chance of being assigned to either group. This randomization can eliminate prior differences between the two groups. To ensure homogeneity between the two groups, it is also required to test behavior before and after experiments. True experiments, conducted in contrived settings that are planned and controlled research environments for gathering data, can enhance internal validity by controlling for other physical characteristics except intended design interventions (Zeisel, 1981). The weakness of the experiments in contrived settings is limited external validity, because observed behavior in manipulated settings, which reflects only a part of a whole system, cannot be generalized to behavior in natural environments. However, true experiments are rarely feasible, because of the difficulties of contriving environments and random assignments.

Quasi Experiment

Due to the limitations of true experiments, many researchers use a quasi-experimental design that does not randomly assign observations. The internal validity of quasi-experiments without randomization is threatened because it is uncertain whether observed behavior results from design intervention of interest or other factors. For instance, even if people in neo-traditional neighborhoods tend to walk more than those in typical suburbs, it is difficult to know whether the difference is caused by the neighborhood design or other factors, for example residential self-selection by neo-traditional residents to satisfy preference for walking. Thus, researchers should try to solve this problem of weak internal validity by "as if random" assignments that hold control factors constant across groups as much as possible. For example, a precisely defined population can enable researchers to match socio-economic characteristics of a sample population. Quasi-experiments are generally conducted in natural settings. Although natural settings have disadvantages in asserting internal validity because of the difficulty in controlling for other characteristics, the advantage of experiments in natural settings is their enhanced external validity, compared to that in contrived settings.

3.2.5. Specific Modeling Precedents

One of problems of quasi-experiments without random assignment is the so-called "self-selection" problem, which means the uncertainty of the extent to which observed behavior can be attributed to the built environment *per se*, as opposed to the prior selection of residents into the built environment that matches their residential and behavioral inclinations. For example, people who prefer walking are more likely to choose walkable neighborhoods than typical suburban neighborhoods. Therefore, difference in walking activities between the two types of neighborhoods can be, at least partially, attributed to self-selection of neighborhoods. In this case, it is likely that the effect of the neighborhood environment is overestimated, and thus, the validity of causal inference is in question.

Aiming to show whether a neighborhood's community *and* physical characteristics *produce* different activity patterns, at least two related forms of bias may be present: *simultaneity bias* (for example, individuals who prefer walking choosing to live in walkable neighborhoods); and *omitted variable bias* (unobserved variables, like preferences for walking, produce the travel outcome (walking), but also correlate with neighborhood characteristics).[10] In other words, the presumed exogenous causal variable, the neighborhood, is actually endogenous, which can produce inconsistent and biased estimators. Mokhtarian and Cao (2008) review the issues and possible analytical and research design solutions. Cao et al. (2006) review 38 empirical studies using nine different approaches to control for "self-selection" – direct questioning, statistical control, instrumental variables, sample selection models, propensity score matching, other joint models of residential and travel choices (for example, structural equation models) and longitudinal studies.

Only statistical control and structural equation models are reviewed here. Statistical control directly incorporates attitudes and preferences into the behavioral model, thereby isolating these effects

[10] A sample selection problem may also exist: among the possible sub-samples of baby boomers, factors influencing residential location choice for the age-restricted sub-sample could also influence behavior. In this study, the sample selection problem effectively appears as a form of omitted variable bias (Hebbert, 2008).

from neighborhood-level effects. Studies typically use specialized survey data, including attitudes and preferences (for example, measured on a Likert scale), in a two-step approach: factor analysis on the indicators (since multiple preferences/attitudes are measured); and, behavioral modeling, including fitted values from the first step (for example, Cao et al., 2006, 2010). Problematically, the estimation of the second step is inconsistent because the fitted latent variables (from the first step) include measurement error by dropping error terms (Ben-Akiva et al., 2002).

The latter problem can be addressed with structural equation modeling (SEM), an analytical tool introduced in the travel behavior field in the 1980s (Golob, 2003) and more recently applied to the self-selection issue (Cao et al., 2009). A full SEM uses simultaneously estimated measurement models, for endogenous and exogenous variables, and a structural model, and can capture influences of exogenous on endogenous variables and among endogenous variables (Golob, 2003). SEM measurement models are similar to exploratory factor analytical approaches, except in restricting the parameters defining factors and specifying covariances among unexplained portions of both unobserved and latent variables (Golob, 2003). The estimated parameters make the predicted variance–covariance matrix as similar as possible to the observed variance–covariance matrix, subject to model constraints. SEM can distinguish between direct and total effects and, with simultaneous measurement equations of latent variables, allows consistent incorporation of attitudes and preferences in behavioral models and captures potential bi-directional influences between attitudes and travel behavior (Mokhtarian and Cao, 2008).

Few studies have used SEM to introduce latent attitudinal variables in the built environment/travel behavior context. Abreu et al. (2006) used SEM in analyzing adult workers' travel in Lisbon, treating short- and longer-term travel behaviors and residence and workplace land use characteristics (latent variables identified through exploratory factor analysis) as endogenous variables and individual socioeconomic variables as exogenous. The approach partially accounts for self-selection while not explicitly including attitudinal effects; the structural and measurement models are not estimated simultaneously. Bagley and Mokhtarian (2002) included attitudes in a SEM, including endogenous variables (two residential type variables, one job location variable, three travel demand variables and three attitude variables) and exogenous variables (socio-demographics, lifestyle factors, attitude measures). They found that attitudes and lifestyles exerted the greatest influence on travel behavior, while residential location type had little impact. The study represented neighborhood characteristics via factor scores on two dimensions (traditional versus suburban) and included latent variables as fitted values of factor analysis on indicators, rather than simultaneously estimating structural and measurement equations. Similar to Abreu et al. (2006), their model is path analysis rather than complete SEM.

In summary, for the highly automobile-dependent, yet relatively understudied, baby boomer generation in the suburban US, the essay asks the question: do neighborhood-related characteristics influence local-level recreational walk/bike and social activity trip-making? Drawing from social ecological theory and utility-based travel behavior theory, the analysis aims to discern community (for example, social network) versus physical (for example, street network) influences. Unlike most previous research in this field, this analysis uses full structural equation models, incorporating attitudes and residential choice, to control for self-selection and to account for direct and indirect effects among exogenous and endogenous variables.

3.3. Research Context and Design

Greater Boston includes 164 cities and towns, with 4.45 million persons (in 2000), across 2832 square miles (6107 square km). Just over 20 percent of residents are older adults (US Census Bureau, 2002), a cohort expected to increase by 50 percent between 2000 and 2020 (Heudorfer, 2005). Approximately 8.5 percent of Greater Boston residents in 2000 were "leading-edge" boomers (US Census Bureau, 2002), a group slightly more suburban than the overall population.[11]

These demographic trends, and local land use policies and fiscal considerations, have fueled age-

[11] Based on the share of census population in 2000, accumulated over the corresponding census block centroid's distance from Boston's central business district.

restricted development. Statewide, Heudorfer (2005) found 150 age-restricted neighborhood developments completed or under construction in 93 cities and towns, implying a supply of more than 10,000 housing units, with another 170 age-restricted developments in pre-construction or seeking permissions in 109 towns. Most developments have fewer than 100 dwelling units and include walking paths, meeting rooms, and clubhouses, with fewer providing on-site shops, bike trails, and golf facilities (Heudorfer, 2005)

3.3.1. Survey Design and Data

This chapter extended the research initiated by the dissertation advisors, Professors Eran Ben Joseph and P. Christopher Zegras, as well as Frank Hebbert (2008). This study collected behavioral and socio-demographic data of baby boomers living in suburban Boston, as part of the New England University Transportation Center grant (DTRS99-G-0001). The analysis of this chapter uses parts of these data, including weekly trip counts, psychological indicators, and other socio-demographic characteristics.

The analysis uses a quasi-experimental, cross-sectional research design comparing suburban age-restricted and un-restricted neighborhoods in Greater Boston. The age-restricted neighborhoods were first identified – via real estate listings, information from developers, and other resources[12] – based on the following criteria: built out and occupied; entirely or mainly age-restricted; and "active adult" (for example, not a continuing care facility). Thirty-five age-restricted neighborhoods met the initial criteria. From this list, 20 neighborhoods were selected (see Table 3-1), by filtering out recent developments (to ensure potential residency of at least three years) and small developments (less than 30 units on a single street). The final sampled age-restricted neighborhoods range in size from 40 to 1,100 dwelling units with a mean of 160 and median of 66 units. The models control for the possible influence of neighborhood size by including total street length in each age-restricted and un-restricted neighborhood. Overall, the selected neighborhoods are biased towards more recent developments and/or ones with recent real estate activity.

[12] Heudorfer (2005) inventoried (apparently based on a survey of town officials) age-restricted housing in the state, but did not identify individual developments.

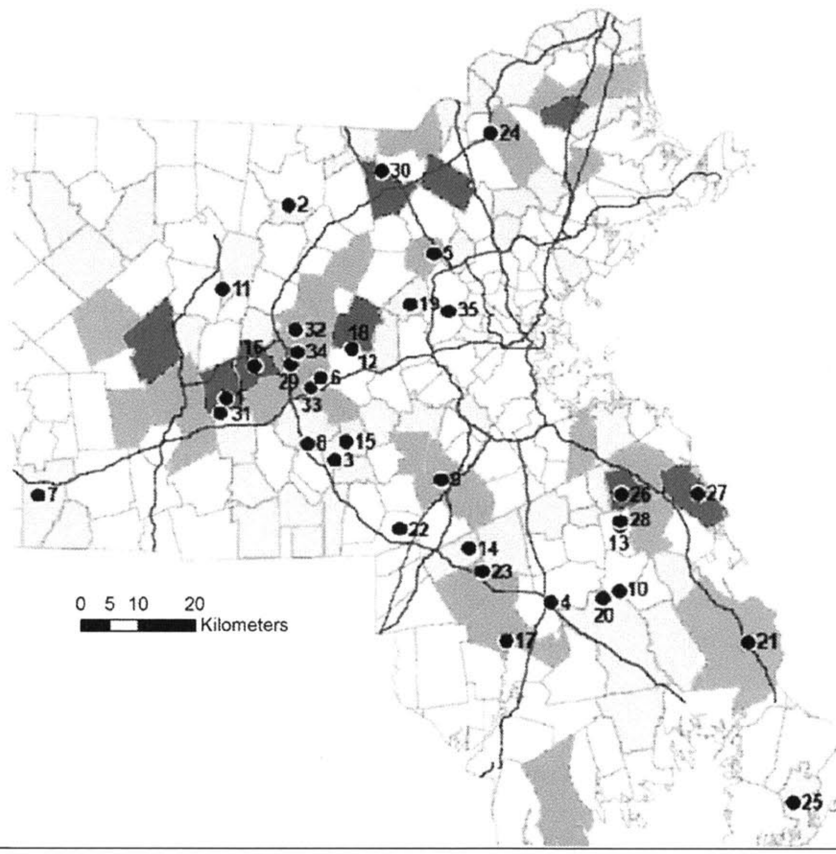
Each age-restricted neighborhood was matched with un-restricted surroundings using postal codes to approximate similar regional accessibility and demographics. Mailing addresses were requested from USAData, a commercial data vendor, for residents aged 55–64, generating 34,108 names. A total of 1,237 households in age-restricted neighborhoods were identified by matching street names against the purchased list. From un-restricted areas, 5,763 households were randomly sampled, producing a total sample size of 7,000 households. This deliberate oversample from un-restricted areas accounted for a lower response rate from the cohort of interest there. Hence, this sampling approach is endogenously stratified.

Mailed survey packages (see Appendix, Figure A-1 and A-2) included a $5 non-contingent cash incentive, a travel survey for retrospective trip counts over the past week; attitudinal questions, such as preferences for walking and cycling (five-point Likert scale); and household/individual questions (for example, income, employment status). Among 1,650 household responses, the final data set includes 1,422 households after excluding problematic responses (effective response rate of 20 percent): 349 from age-restricted neighborhoods (28 percent response rate) and 1,073 from un-restricted neighborhoods (19 percent response rate). Problematic responses included: addresses non-geo-locatable or outside the study area (due to mail forwarding); no household survey page; age outside the cohort of interest. [13]

Among the 20 age-restricted neighborhoods, responses came from 15 (Table 3-1). Households included 1,859 individuals (470 age-restricted; 1,389 un-restricted). Individual household locations were geocoded and aggregated into 250-metre grid cells. The grid cell approach ensures anonymity, making it impossible to identify the household's address. The centroid of the 250-metre grid cell serves as the household "location." Each grid centroid was visually associated to a neighborhood based on primary street characteristics (see Figure 3-1).

[13] Hebbert (2008) provides detail on survey design, implementation and results.

Table 3-1. Age-Restricted Neighborhoods Examined (15 from which residents responded)



ID	Community	Households	Persons
1	Adams Farm	14	21
8	Deerfield Estate	7	10
9	Delapond Village	2	2
11	Eagle Ridge	11	15
17	Leisurewoods	25	31
20	Oak Point	95	128
21	Pinehills	87	116
23	Red Mill	6	8
25	Southport	35	45
27	Spyglass Landing	5	6
30	The Village at Meadwood	16	22
31	The Village at Orchard Meadow	17	23
32	Village at Quail Run	11	15
33	Vickery Hills	14	23
35	Wellington Crossing	4	5
Total		349	470
Response rate		28%	

Notes: The shading of the map indicates towns with one or more ARAACs, as tabulated by Heudorfer (2005). Numbered dots indicate locations of ARAACs identified for this study.

Measures of Neighborhood Characteristics

Suburban neighborhood characteristics were measured using a Geographic Information System (GIS) and public and private data sources. These include: MassGIS,[14] Google Earth, and Environmental Systems Research Institute (ESRI). [15] Basic data, including roads, parcels, commuter rails, etc., come from MassGIS. Unfortunately, many important data layers do not exist, and moreover, available data files are obsolete. For example, no building footprint data for our sample neighborhoods could be located and, in the relatively new age-restricted neighborhoods, road networks are outdated. The missing data was updated using a high-resolution aerial photo from ESRI, to identify street patterns and compute intersection density. Other neighborhood characteristics – such as public spaces, outdoor sports facilities, destinations, and bus stops – were measured with Google Earth's satellite imagery and "Places" layer, and, in some cases, site plans and descriptions of neighborhood features from age-restricted neighborhoods' web-pages. For the morphological study, physical characteristics of age-restricted neighborhoods were collected using online tools (such as Google Earth, Google Street View, and Microsoft Visual Oblique), neighborhoods' websites, and real estate journals.

Boundaries of suburban neighborhoods were generally determined by major roads and/or natural elements (greenery or water). Relative to un-restricted neighborhoods, the boundaries of master-planned, age-restricted neighborhoods were clearly defined with their entrances to neighborhoods and internal street networks (see Figure 3-1). Within these boundaries, the following neighborhood characteristics were objectively measured:

- *Street Pattern*: Prototypical street configurations: linear, loop, and grid (see Figure 3-1). Linear type neighborhoods are generally comprised of cul-de-sacs without circular routes. The street pattern of loop type neighborhoods provides pedestrian circulation. Grid type neighborhoods can be accessed via multiple entrances and include multiple circular, internal, pedestrian routes.
- *Intersection Density*: True intersection density (True intersections / 100m of streets)

[14] http://www.mass.gov/mgis/
[15] http://www.arcgis.com/

- *Neighborhood Facilities*: Presence of public spaces or sports facilities in neighborhoods
- *Accessibility to Destination*: Presence of "places of interest" on Google Earth within 400m
- *MBTA Bus Stop*: Presence of MBTA bus stops within 1km
- *Commuter Rail*: Presence of Commuter rail within 1km

3.3.2. Measures and Descriptive Statistics

Table 3-2 includes descriptive statistics of key variables, including outcomes of interest, reported weekly: NMT trips, representing recreational walking/biking trips; and social trips, measuring visits to neighbors and representing local social engagement. Respondents in age-restricted neighborhoods have only slightly higher average weekly trip rates for both trip purposes. A large share of individuals in both neighborhood types report making zero NMT and social trips during the week (hereafter, these individuals are "non-active" and "non-social"). Un-restricted neighborhoods have a 10 percent higher share of non-active and a 13 percent higher share of nonsocial individuals. Baby boomers residing in age-restricted neighborhoods tend to be less employed, slightly healthier and slightly older, with fewer owning a bike or more than three cars.

Age-restricted neighborhoods have more local facilities, such as public spaces, and, primarily, loop street patterns. None has grid streets. Nearly 50 percent of un-restricted neighborhoods have linear street patterns. Other physical characteristics – such as intersection density, destinations and proximity to public transport – do not significantly differ between sampled restricted/un-restricted neighborhoods.

Exploratory factor analysis on the responses to the questions regarding residential preferences hypothesized latent variables. The primary purpose of factor analysis is to reduce the number of variables and identify underlying constructs in the relationships among a large set of variables. Principal component analysis (PCA), which is the most common type of factor analysis, uses a correlation or covariance matrix to determine the common *and* unique variance of the variables (Everitt & Dunn, 2001).

Basically, PCA seeks a linear combination of variables to maximize the variance. This maximum variance is captured by the first component; the next component provides a linear combination of the variables, which explains the greatest amount of the remaining variance, subject to not being correlated to the first component. All remaining components are subsequently derived, analyzing total (common and unique) variance and producing components that are uncorrelated (orthogonal). PCA derives composite latent variables based on the responses to the original preference, attitudes, and demographic questions, using PCA. The derived composite variables not only reduce the number of variables but also detect original indicators' the latent structure, which is not directly observable.

The PCA in this analysis derived two latent variables: Pro Walkability, denoting preference for walkable neighborhoods, and Pro Segregation, representing preference for neighborhoods segregated by age and social class (Appendix, Table A-1). Confirmatory factor analysis confirms this latent structure: fixing the indicators most highly correlated with the two latent variables at 1 for identification, all other indicators significantly contribute to the latent variables (Appendix, Table A-2). This latent construct serves as a measurement model in the following SEM.

Table 3-2. Descriptive Statistics by Neighborhood Type and Tests of Differences

Variables		Total		Group Mean (SD)		
		N	Mean (SD)	Age-Restricted	Un-Restricted	Mean Diff.
NMT Trip	Last week, how many times did you walk or cycle for exercise in your neighborhood?	1761	2.235 (2.417)	2.629 (2.451)	2.101 (2.391)	0.528**
	Individuals reporting *zero* NMT Trips over past week (i.e., "non-Active)	704	0.400	0.324	0.426	0.102**
Social Trip	Last week, how many times did you visit your neighbors?	1755	0.801 (1.322)	1.084 (1.472)	0.706 (1.253)	0.378**
	Individuals reporting *zero* social Trips over past week (i.e., "non-Social)	1075	0.613	0.514	0.646	0.132**
ARAAC	Age-restriction status (0. not restricted, 1. age-restricted)	1859	0.253	-	-	-
Employ	Employment status (0. unemployed, 1. employed)	1846	0.637	0.510	0.680	0.170**
Healthy	Health status (0. unhealthy, 1. healthy)	1859	0.851	0.892	0.837	0.054*
Male	Gender (0. female, 1. male)	1849	0.472	0.444	0.482	0.038
Age	Residents' age	1760	61.195 (3.875)	62.651 (3.750)	60.687 (3.790)	1.963**
High-Income	High annual household income ($100k- more) (0. otherwise, 1. high income)	1761	0.298	0.330	0.287	0.043
Mid-Income	Medium annual household income ($50k-99.9k) (0. otherwise, 1. medium income)	1761	0.496	0.501	0.495	0.006
Low-Income (base)	Low annual household income (less than 49.9k) (0. otherwise, 1. low income)	1761	0.205	0.169	0.218	0.049*
Three Vehicles	Three and more vehicles in a household (0. less than 3 vehicles, 1. 3+ vehicles)	1668	0.259	0.137	0.301	0.164**
Bike	Bikes in a household (0. No bicycles, 1. More than one bicycles)	1645	0.573	0.519	0.592	0.072**
Grid	Neighborhood street patterns Grid type (0. otherwise, 1. grid)	458	0.234	-	0.242	0.242*
Loop	Neighborhood street patterns Loop type (0. otherwise, 1. loop)	458	0.295	0.800	0.278	0.522**
Linear	Neighborhood street patterns Linear type (0. otherwise, 1. linear)	458	0.472	0.200	0.481	0.281*
Intersect Density	True intersection density (True intersections / 100m of streets)	458	0.322	0.392	0.320	0.072
Facilities	Presence of public spaces or sports facilities in neighborhoods (0. no, 1. yes)	458	0.349	0.733	0.336	0.397**
Destination 400	Presence of "places of interest" in Google Earth within 400m (0. no, 1. yes)	458	0.448	0.600	0.442	0.158
MBTA Bus Stop	Presence of MBTA bus stops within 1km (0. no, 1. yes)	458	0.066	0.133	0.063	0.070
Commuter Rail	Presence of commuter rail within 1km (0. no, 1. yes)	458	0.222	0.200	0.223	0.023
Street Length	Total street length of a neighborhood (km)	458	2.977	5.396	2.895	-2.501

Notes: * $p<0.05$, ** $p<0.01$, indicating significance levels of difference of means/proportions; 1km = 0.62 mi; 400m = 0.25 mi; 100m = 0.06 mi = 318 ft; - : indicates not applicable; Some totals differ due to missing items in the sample.

3.4. Behavioral Modeling

The large share of zero-reported NMT and social trips (Table 3-2) indicates censoring – ordinary count models may be inappropriate. A zero-inflated model allows zeros to remain in the count model by estimating an individual's likelihood of being in the 'zero' group. Taking recreational NMT trips as an example, a binary logit model estimates the probability of being non-active and active. These probabilities weight the zeros in the count model such that the probability of observing zero for an individual equals the probability of being non-active plus the probability of being active, multiplied by the probability of observing zero in the count model (see Figure 3-2, Equations (1)–(3)) (Jones, 2005). This produces two sets of coefficients. The logit model results indicate the variables' influence on the likelihood of being non-active; negative coefficients imply a higher probability of being active. The count model estimates trip counts for the active group; positive coefficients mean a higher frequency of recreational NMT trips.

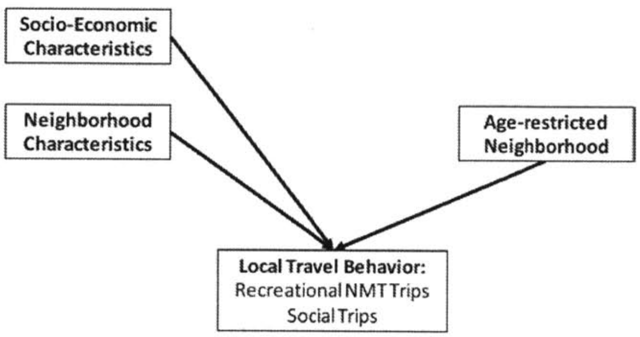
Zero-inflated negative binomial (ZINB) models[16] with SEM simultaneously incorporate attitudes possibly affecting residential choice/travel behavior and a residential choice model. Three types of relationship are examined – residential choice, residential preference, and travel behavior (Figure 3-2) – and three models are estimated (Appendix, Table A-3 and A-4 provide full results). Model 1 has no control for self-selection. Model 2 attempts to control for individuals' self-selection for neighborhood physical characteristics by simultaneously estimating the ZINB model and the latent variable (attitudinal) model's structural and measurement equations. Model 2 estimates residential preferences conditional upon socioeconomic characteristics; thus, travel behavior and residential preferences are endogenous while socioeconomic status and neighborhood physical characteristics and age-restricted status are exogenous.

[16] For the NMT and social trip models, the Vuong test indicates that ZINB is preferable to a regular negative binomial; and a likelihood ratio test indicates that ZINB is preferable to a zero-inflated Poisson.

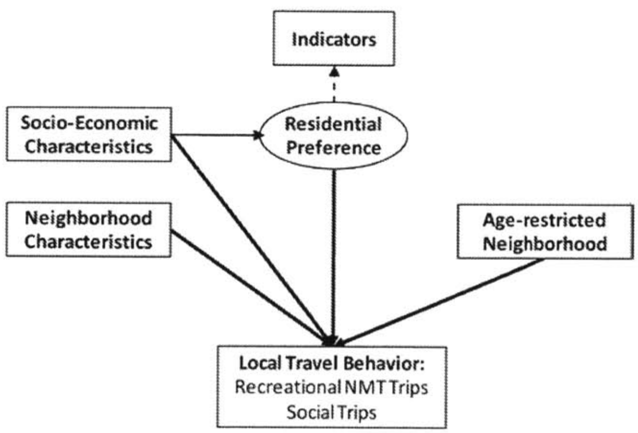
Figure 3-2. Path Diagrams and Equations of Three Models That Hypothesize Relationships among the Built Environment, Residential Preference, and Travel Behavior

Path Diagrams

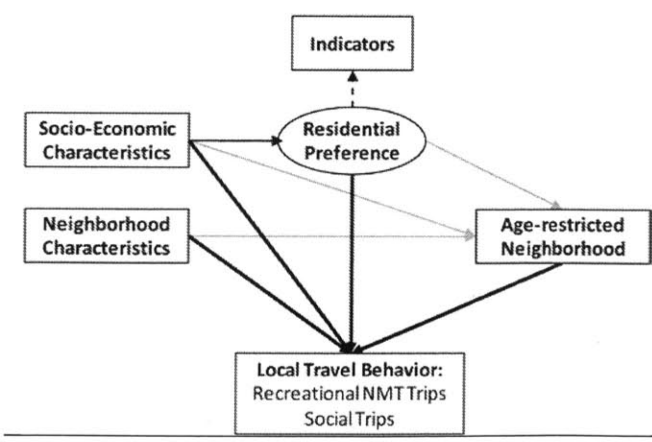
Model 1: Zero-Inflated Negative Binomial Model Without Latent Variables



Model 2: Zero-Inflated Negative Binomial Model With Latent Variables (MIMIC Model)



Model 3: Zero-Inflated Negative Binomial Model With Age-Restricted Neighborhood Choice (Logit) Model



Equations

⟶ : Zero-Inflated Negative Binomial (ZINB) Model

Logit Model: (Eq. 1)

$$\text{Logit}(\mu=0) = X\beta + Z\gamma + L\rho + \varepsilon$$

$$P(y_i = 0) = \pi = 1 / e^{-(X\beta+Z\gamma+L\rho)}, \quad y_i = 0, 1, 2, 3, \ldots$$

Negative Binomial Model (NB): (Eq. 2)

$$\ln Y = X_{nb}\beta_{nb} + Z_{nb}\gamma_{nb} + L_{nb}\rho_{nb} + \zeta$$

$$P(y_i \mid x_{nb,i}, z_{nb,i}, l_{nb,i}) = e^{-\mu_i}\mu_i^{y_i} / y_i!, \quad y_i = 0, 1, 2, 3, \ldots$$

$$E(y_i \mid x_{nb,i}, z_{nb,i}, l_{nb,i}) = \mu_i = e^{(X_{nb}\beta_{nb} + Z_{nb}\gamma_{nb} + L_{nb}\rho_{nb})}$$

$$V(y_i \mid x_{nb,i}, z_{nb,i}, l_{nb,i}) = \mu_i(1 + \alpha\mu_i)$$

Combining the logit and NB models: (Eq. 3)

$$P(y_i \mid x_i, z_i, y_i, x_{nb,i}, z_{nb,i}, y_{nb,i})$$

$$= \pi + (1-\pi)\, P(0 \mid x_{nb,i}, z_{nb,i}), \text{ if } y_i = 0$$

$$(1-\pi)\, P(0 \mid x_{nb,i}, z_{nb,i}), \text{ if } y_i > 0$$

X	Neighborhood Characteristics
Z	Socio-economic Characteristics
L	Latent Variables (Residential Preference)
Y	Count of activities
μ	Expected count
π	Probability of being in zero-count group
α	Variance (Dispersion) parameter
β, γ, ρ	Unknown parameters
ε, ζ	Random disturbance terms

Structural Equation Model (SEM)

⟶ : Structural Model (Eq. 4)

$$L = Z\eta + \xi, \quad \xi \sim N(0, \psi_\xi \text{ diagonal})$$

- - → : Measurement Model (Eq. 5)

$$I = L\lambda + \delta, \quad \delta \sim N(0, \varphi_\delta \text{ diagonal})$$

Z	Socio-economic Characteristics
L	Latent Variables (Residential Preference)
I	Indicators of L
η, λ	Unknown parameters
ξ, δ	Random disturbance term
ψ, φ	Covariances of random disturbance term

⟶ **: Age-Restricted Choice (Logit) Model**

$$P(\textit{Age-restricted} = 1 \mid X, Z, L) = 1 / e^{-(X\theta + Z\iota + L\kappa)} \quad \text{(Eq.6)}$$

X	Neighborhood Characteristics
Z	Socio-economic Characteristics
L	Latent Variables (Residential Preference)
θ, ι, κ	Unknown parameters

Model 3 includes a binary choice model for age-restricted status, assuming that people select age-restricted neighborhoods to satisfy community preferences, and that neighborhood and individual characteristics influence age-restricted choice. As mentioned in the sample description, the sample is endogenously stratified. In the age-restricted neighborhood choice (logit) models, this choice-based sampling results in an inconsistent alternative specific constant, while other coefficients are consistent (Manski and Lerman, 1977). Weights in the choice model estimation are used to correct for this sampling strategy: p/s for households in age-restricted communities and $(1-p)/(1-s)$ for households from un-restricted communities, where p is the probability of a household living in an age-restricted community from the population and s is the proportion of households from the sample living in an age-restricted community. As a value for p is not available, 3.2 percent is used (Emrath and Liu, 2007). The sensitivity of results to this value was tested by estimating the models with $p = 1$ percent and 5 percent (reasonable upper and lower bounds); the results do not vary substantively. Full sensitivity analyses are presented in Appendix, Table A-5 and Table A-6.

In this case, age-restricted neighborhood choice, residential preferences and individual and neighborhood characteristics jointly affect local travel behavior. Mplus 5.0 estimated the models, using a normal theory maximum likelihood (ML) estimator with robust standard errors and accounting for non-independence among observations from the same household (Muthen, 1998–2004; Muthen and Muthen, 1998–2007). This study sampled households but modeled individuals' behavior, and thus needs to account for potential correlation of behavior among same-household individuals (i.e., intraclass correlation). One option MPlus provides for dealing with this issue is correcting standard errors. With sampling weights, parameters are estimated by maximizing a weighted loglikelihood function. Standard error computations use a sandwich estimator; using this approach, the SEs in Tables A-3 and A-4 are corrected. Intraclass correlation among households from the same neighborhood may also exist, indicating the need for a multilevel SEM ZINB model. Mplus codes are provided in the Appendix, Table A-15.

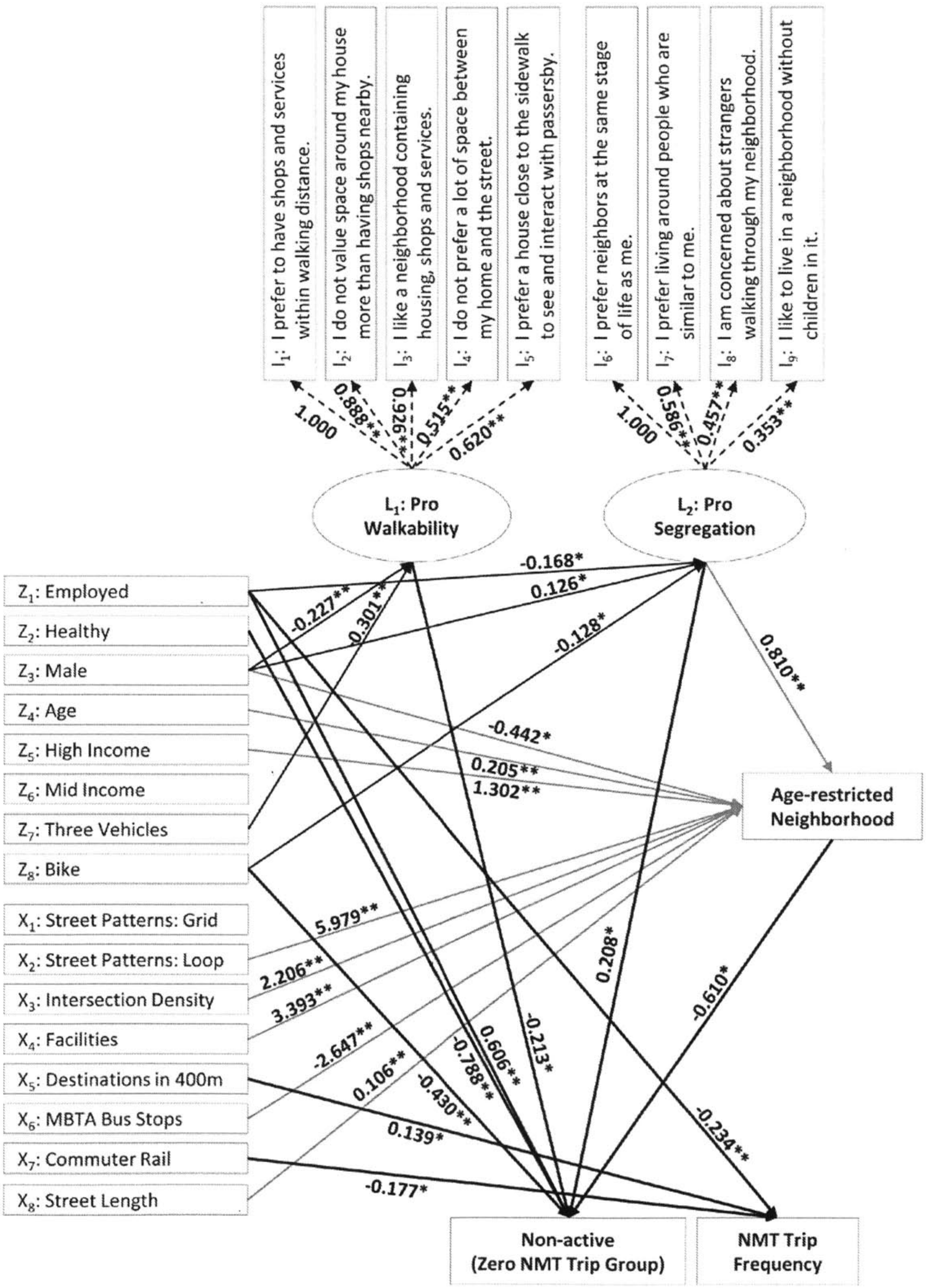
3.4.1. Recreational NMT

The recreational NMT trip results directly support the first hypothesis regarding the effect of age-restricted setting, with some support for neighborhood physical characteristics, but only "bundled" with age-restriction. Figure 3-3 orients the discussion. Examine, first, the age-restricted neighborhood choice: after controlling for neighborhood characteristics, age-restricted neighborhoods attract older, higher-income people who prefer segregated neighborhoods. Males are less likely to choose age-restriction. Age-restricted neighborhoods with loop-type streets, higher intersection density and on-site facilities are more attractive.

Looking at the likelihood of being non-active, neighborhood physical characteristics – loop street type, intersection density, presence of local facilities, and total street length – do have an influence, but only indirectly, via the age-restricted choice. Community and design primarily influence the non-active likelihood, with only nearby destinations exerting a significant effect on number of trips among the active. Nearby commuter rail, interestingly, negatively correlates with number of recreational NMT trips.

For individuals, being employed increases the likelihood of being non-active and decreases the number of NMT trips among the active. Being healthy decreases the likelihood of being non-active. Finally, "pro-Walkables" are less likely to be non-active, while "pro-Segregated" are more likely to be. This latter effect is partly offset by the pro-Segregated choosing age-restricted neighborhoods that, in turn, increase the likelihood of being active. There is little evidence of self-selection for local NMT trips. While both latent attitudinal constructs significantly affect the choice to be active, they do not change the sign, significance, or magnitude of the age-restricted effect (see Appendix, Table A-3). Age-restricted community settings increase the chance that residents will make local recreational NMT trips – perhaps, in part, due to neighborhood physical characteristics. Other than nearby destinations' effect on NMT trip counts, neighborhood physical characteristics do not directly affect baby boomers' being active or the number of recreational NMT trips.

Figure 3-3. Path Diagram and Results of the Recreation NMT Model



Notes: Results from Model 3 in Appendix Tables A-3; † p<0.10, * p<0.05, ** p<0.01

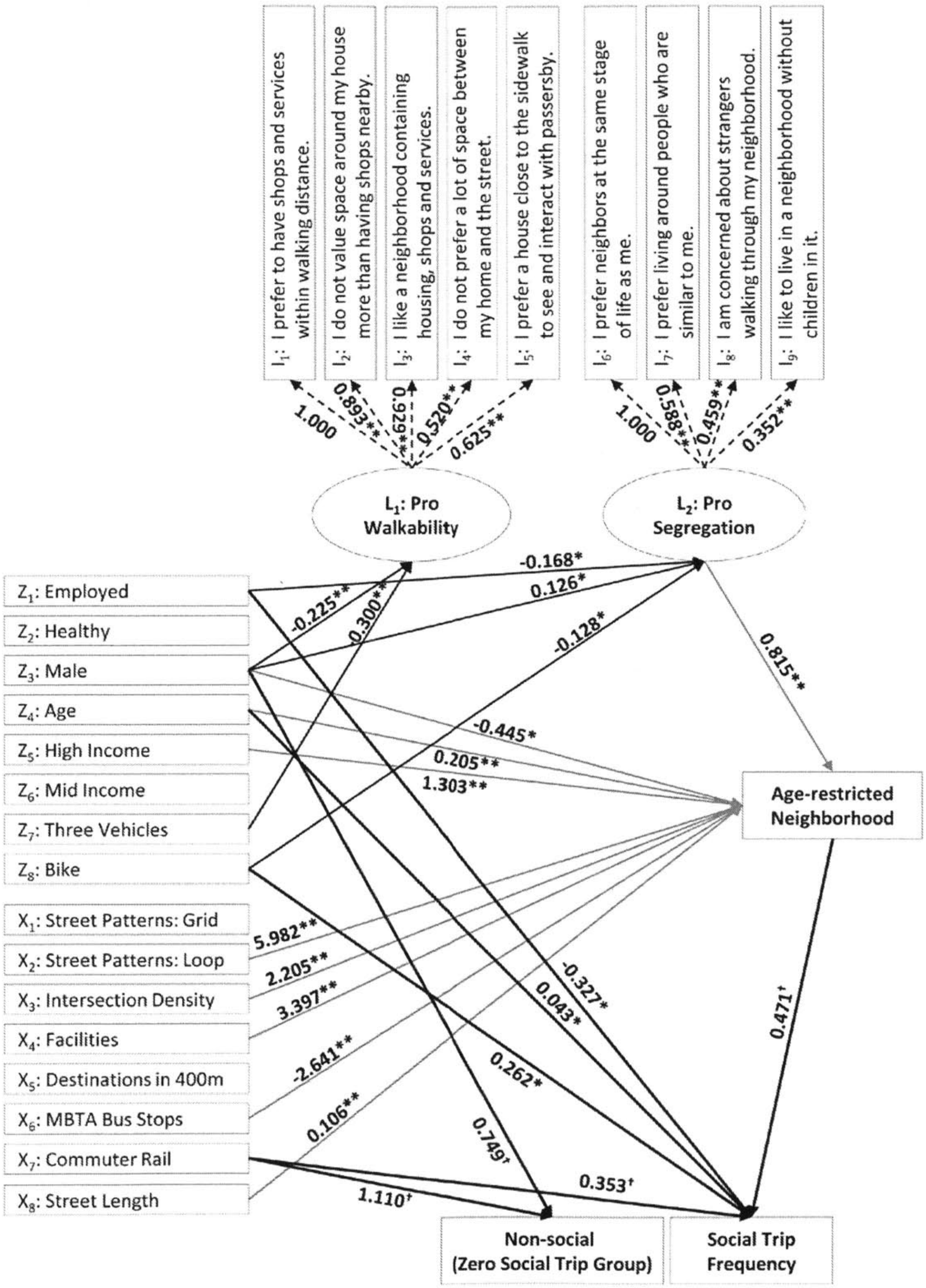
3.4.2. Social Trips

The social trip results also only partially support the hypotheses, with distinct, somewhat counter-intuitive, differences relative to recreational NMT. Age-restricted settings and, indirectly, their bundled physical characteristics exert an uncertain influence on the number of social trips. Physical characteristics themselves only modestly (and uncertainly) influence the likelihood of being "social." Figure 3-4 guides the discussion.

The same age-restricted choice model as for recreational NMT holds. However, contrary to the NMT case, age-restricted neighborhoods do not affect being social; among the social, age-restriction increases social trip-making. This result should be viewed with some uncertainty (p-value = 0.075) and suggests residential self-selection vis-á-vis social trip-making (compare the significance of the age-restricted neighborhood coefficient from model 1 with models 2 and 3; Appendix, Table A-4). Those inclined to make more social trips may select age-restricted settings (and, possibly, their physical characteristics) to satisfy social trip-making tendencies. Regarding direct physical effects, street typologies are insignificant. Nearby commuter rail is associated with being social and making more local social trips ($p<0.10$).

For individuals, being employed increases the likelihood of being non-social. Unsurprisingly, being employed reduces weekly local social trip-making. Older boomers have greater likelihood of making more social trips. Finally, those preferring segregated neighborhoods have a higher likelihood of making more social trips. Social trips offer stronger evidence of self-selection in this study. While age-restricted neighborhoods appear to be associated with more weekly social trips among the socially inclined, statistical support for this effect declines once one accounts for attitudes and residential preferences

Figure 3-4. Path Diagram and Results of the Social Trip Model



Notes: Results from Model 3 in Appendix Tables A-4; † $p<0.10$, * $p<0.05$, ** $p<0.01$

3.5. Implications and Shortcomings

The findings must be viewed in light of the demographic geography of baby boomers in the metropolitan US: the majority live in auto-dependent suburbia. Among the sampled individuals, for example, 93 percent of daily reported trips were by automobile (Hebbert, 2008), even higher than the automobile mode share for Greater Boston's baby boomers.[17] This study sheds little light on the larger challenges implied. Nonetheless, with respect to two types of local travel activities that may be influenced by suburban neighborhood and community characteristics and play an important role in healthy aging, some influences emerge.

The models identify modest effects of neighborhood age-restricted status and physical characteristics on weekly recreational NMT and social trip-making. Distinguishing between those who do and do not make a recreational NMT or social trip provides useful information. Eyler et al. (2003), studying adults in the US, identified three types of walker: regular, occasional, and never. Occasional and never walkers lacked time for walking and never walkers reported feeling unhealthier, while regular walkers reported more self-confidence and social support for walking. The recreational NMT results support these findings and suggest a design and community (social network) role: those with a "pro-Walkable" mindset are more likely to be active; the community and, indirectly, design aspects of age-restricted neighborhoods increase residents' likelihood of being active, after controlling for self-selection.

This provides some support for the social ecological model of health promotion – the social-physical setting of the age-restricted neighborhoods apparently provides a medium for active living (for example, Wister, 2005). Among the active, however, the neighborhood has no effect on increased recreational NMT trip-making, although nearby destinations do play a role. The age-restricted effect may come from social settings (i.e., community) or other unobserved (or non-comparable) physical

[17] The differences may partially result from undercounting in the survey. The 55–65-year-old cohort at the time of the most recent Boston metropolitan area travel survey (in 1991) had an automobile mode share of 89 percent (CTPS, 1993); the most recent national travel survey, although with only 194 baby boomers from the Boston MA, indicates a 78 percent automobile mode share for all trips by this cohort (US DOT, 2009).

characteristics distinguishing age-restricted from un-restricted suburbs. For example, the age-restricted neighborhoods studied have more local facilities (for example, clubhouses) than typical suburbs (Table 2); while insignificant in the NMT models, these variables' effects may be masked by the age-restricted label.

As in the recreational NMT case, some age-restricted physical characteristics (intersection density, neighborhood facilities and destinations) indirectly influence social trip-making among the social. In this case, however, residents may be purposely choosing age-restricted settings and their related design attributes: age-restricted settings will not "make" people social, but may attract those with higher social trip-making tendencies.

These findings indicate the importance of distinguishing between trip types, including when attempting to control for self-selection. The results confirm intuition: an individual may choose a neighborhood to satisfy desired local social activity; this residential choice to satisfy one activity preference might then induce changes in other activities.

3.5.1. Limitations and Future Research

The results are only directly applicable to a specific demographic, geography and time of year (i.e., April 2008) and may not be generalizable. Even for the specific groups and areas studied, it is likely that the sampling procedure suffers from biases that further limit the results' validity and generalizability.

The age-restricted effects may be confounded by not knowing whether some of the un-restricted neighborhoods also have a high share of older adults (i.e., being NORCs), implying similar community structures. This relates to spatial dependence – participation in a particular activity may be influenced by surrounding neighborhoods, including how well "integrated" the neighborhoods are with their surroundings, only crudely proxied here. The age-restricted neighborhoods' relative newness may also confound; newer residents[18] may still be "exploring" surroundings, effects indistinguishable from the age-restricted status. Over time, such effects may diminish or intensify – an area for further study.

[18] Residents of age-restricted neighborhoods report having lived there on average for 5 years, compared with 19 years for un-restricted neighborhoods (Hebbert, 2008).

Complete SEM – simultaneously estimating measurement models of latent attitudinal variables and behavioral (structural) models – represents an important advance. It controls for self-selection based on attitudes and residential choice and allows testing more complex relationships, including direct and indirect effects. The increased modeling sophistication also comes at a cost – the particular SEM cannot easily reveal relative or marginal effects, only significance and directionality. Furthermore, the design remains cross-sectional, as opposed to temporal (i.e., measuring change). For example, people living in a sociable community and/or a social-oriented neighborhood may increase, over time, their socializing, which may then change the community (for example, walking groups); revealing these dynamics would require longitudinal analysis.

Questions can be raised about the outcomes measured: self-reported recreational NMT trips in the neighborhood and social trips to "neighbors." Respondents may interpret the extent of "neighborhood" and/or "neighbors" differently. Further, the measures may be weak proxies for outcomes more closely related to healthy aging, such as: minutes of activity per day, health conditions, levels of social engagement, strength of social networks, and/or mental health conditions. Analogously, the validity and reliability of the attitudes/preferences questions are uncertain and treating the ordinal Likert-value attitude scores as continuous variables (in the factor analysis), although common practice, may be problematic.

The analysis investigated neighborhood environments with "objective" measurement, which may not account for design qualities like sense of safety and human scale (Ewing and Handy, 2009) and may ignore individual perceptions of relevant factors. Again, these perceptions may change over time and be influenced by neighborhood and/or community changes. Enhanced behavioral insights might come from combining qualitative measures of the built environment with "objective" measures.

Further research could examine additional travel behaviors among baby boomers and/or compare suburban and urban baby boomers or age-restricted neighborhoods with non-age-restricted master-planned neighborhoods. Such comparisons may reveal whether the modest behavioral effects of age-restricted neighborhoods derive from the community structure, physical features, or their reciprocal interactions. Additional topics worth examining include: the potential to retrofit existing neighborhoods to serve the needs of baby boomers more effectively; whether spatial concentrations of baby boomers in suburbia increase possibilities for new transport and/or other older adult services; and the relationship between commuter rail proximity and local trip-making.

The results indicate the need to reach a better understanding of how physical and social structures interact to influence baby boomers' activities. Overall, however, the relative locations of older-adult-oriented neighborhoods need attention. For example, just 13 percent of the age-restricted neighborhoods studied are within 1 km of a bus stop and 20 percent within 1 km of commuter rail. As aging means reduced driving capabilities, this relative automobile-dependency may pose a problem.

3.6. Conclusion

A neighborhood type catering to baby boomers – age-restricted, active adult neighborhoods – is studied to discern community (for example, social network) versus physical (for example, street network) influences on suburban baby boomers' travel behavior. Using structural equation models, the analysis attempts to control for self-selection based on attitudes and residential choice, allowing for direct and indirect effects among exogenous and endogenous variables.

The age-restricted neighborhoods attract older, higher-income baby boomers who prefer age-segregation. These communities increase the likelihood of boomers being active – i.e., making at least one local recreational NMT trip – but not the number of NMT trips among the active. Physical characteristics have only an indirect effect, by influencing the decision to live in age-restricted settings. In contrast, age-restriction has no effect on being social (i.e., the likelihood of ever visiting neighbors); among the social, however, age-restriction increases social trip-making, although perhaps due to self-selection. In other words, age-restricted neighborhoods are associated with higher levels of local social activity, but because they attract more socially inclined residents. The age-restricted effect may stem from a sense of community fostered in age-restricted neighborhoods and/or unobserved or intermingling physical characteristics.

The analysis indicates the importance of distinguishing between trip types when controlling for self-selection in the built environment/travel behavior research. It also suffers from a range of limitations, including generalizability, unknown relative magnitude of effects, and inability to assess impacts over time. While this research says nothing about the regional travel patterns of this highly suburbanized, automobile-dependent generation, it offers some insight into the influence of age-restricted neighborhoods on baby boomers' local travel behaviors.

Chapter 4

Safely Active Mobility for Urban Baby Boomers: The Role of Neighborhood Design

4.1. Introduction

The growing number of older adults in the US continues to raise concern about active and safe aging. While researchers in public health, urban planning, and related fields have emphasized the health and environmental benefits of physical activities, including "active travel" (e.g., walking and biking) (Boarnet et al., 2008), many older adults do not achieve recommended levels of physical activity (King et al., 1998). Traffic safety concerns may play a role. For example, the relatively lower accident involvement rates for older persons may reflect a risk aversion: older pedestrians involved in traffic accidents are much more vulnerable to serious injury or death than younger pedestrians (NHTSA, 2009). Thus, lower levels of walking by older adults may indicate an effort to reduce risk exposure (PEDSAFE, 2004).

This situation poses a potential dilemma. Urban designers, planners, and others continue to advocate for urban design interventions as a way to encourage public and non-motorized transportation use. At the same time, local governments have developed specific plans to improve pedestrian safety, focusing on urban design interventions and education programs for drivers and pedestrians (Hunter & Hunter, 2008; New York City Department of Transportation, 2010). Are the dual goals of increasing older adults' walking levels and increasing the safety of the walking environment compatible? Despite considerable research on the relationship between the built environment and physical activity, in general, relatively little of this research has focused specifically on older adults. Furthermore, little is known about how urban form and safety interact to influence older adults' walking behavior. In a recent strategic plan on pedestrian safety, the U.S. Federal Highway Administration recognized the need for improved knowledge of the relationship between the built environment and walking, including effects on safety (Zegeer et al., 2010). Here this study examines, simultaneously, the inter-twined relationships among neighborhood form, traffic safety and baby boomers' walking behavior.

This chapter focuses on urban, as opposed to suburban, baby boomers. Walkable urban forms in urban areas can promote urban baby boomers' walking, but they are also often associated with higher traffic accident rates (Ewing & Dumbaugh, 2009; Moudon et al., 2011); these, in turn, are negatively correlated with walking (Owen et al., 2004; Bauman & Bull, 2007). A possible public health tradeoff then emerges: walkable environments might increase healthy living opportunities while at the same time increasing traffic accident risks (Miranda-Moreno et al., 2011).

The study investigates the relationships between urban form, baby boomers' walking behavior, and traffic safety, by (1) analyzing the spatial patterns of traffic accidents and (2) developing behavioral models which attempt to assess the causal impact of neighborhood-level urban form and spatial patterns of traffic accidents on baby boomers' walking behavior. The ultimate aim of this study is to improve neighborhood environments, so as to promote more environmentally benign, and physically active and safe mobility for baby boomers.

The remainder of this chapter introduces the empirical and analytical background for the research; outlines the conceptual framework and specific research questions; describes the setting and methods; and presents the results, implications, and shortcomings. A final section presents conclusions.

4.2. Background and Research Questions

4.2.1. Research Precedents

The Built Environment and Older Pedestrians

The health benefits of physical activity for older adults are well-known. Moderate levels of daily physical activities reduce the risks of high blood pressure, heart disease, colon cancer, and diabetes, as well as depression (Nelson et al., 2007). Walking and cycling for daily travel offer an affordable, reliable and theoretically feasible way to achieve recommended physical activity levels (Pucher & Dijkstra, 2003). Nonetheless, approximately a third of older adults (55 and older) in the US are physically inactive (King et al., 1998). Does research reveal a relationship between the built environment and older adults' physical activity? The evidence is mixed.

Density and diversity of land uses are oft-analyzed built environment measures, generally serving as a proxy for the intensity of overall neighborhood activities. Higher density may increase walking levels by, for example, shortening potential trip distances. More land use mix may exert similar influences, including by increasing the utility of a single trip tour by increasing the types of destinations available along the way and decreasing the distances between them. Density and diversity may also impact perceptions of the walking environment. For older adults, Li et al. (2005) find a correlation between density of employment and households and walking and Berke et al. (2007) find a statistically significant relationship between dwelling unit density and walk frequency. Satariano et al. (2010) find that older adults in mixed-use or commercial areas tend to spend more time walking, relative to those in residential areas. In contrast, Hall and McAuley (2010) find no significant difference in land use mix or land use diversity between older women who walk more than 10,000 steps per day and those who walk less than 10,000 steps.

A related built environment dimension is accessibility to destinations, such as shopping malls, retail shops, and recreational places. The positive effect of accessibility to retail shops on older adults' walking has been consistently identified (Cao et al., 2010; King et al., 2003; Michael et al., 2006; Nagel et al., 2008). The evidence on the accessibility to recreational places such as parks is mixed: Gómez et al. (2010) and King et al. (2003) find significant relationships; Hall & McAuley (2010), Michael et al. (2006), and Nagel et al. (2008) do not. Similarly inconsistent results appear from analyses of effects of transportation infrastructure-related characteristics on older adults' walking activity, including: proximity to walking paths and trails (Hall & McAuley, 2010; King et al., 2003; Michael et al., 2006); proximity to transit stops (Gómez et al., 2010; Nagel et al., 2008); and street connectivity (Li et al., 2005; Hall & McAuley, 2010; Joseph & Zimring, 2007; Nagel et al., 2008; Satariano et al., 2010).

Overall, the empirical evidence remains inconclusive, if not contradictory. In reviews of relevant studies, Cunningham and Michael (2004) and Rosso et al. (2011) discuss causes of these mixed results: (1) lack of a theoretical framework, (2) limitation of cross-sectional data for causal inferences, (3) different measures and operational definitions of neighborhoods, and (4) differences in localities and subpopulations.

The Built Environment and Pedestrian Safety

Within Lawton's theoretical framework, safety represents an important potential environmental press (Lawton, 1973). Generally, safety refers to freedom from dangers, which in the specific context can come from crime, traffic, and other sources (e.g., inadequate physical infrastructures, animals). Safety varies by individual perceptions and can certainly influence walking behaviors. In this particular research, a primary concern is how traffic safety interacts with urban form to influence older adults' behavior. Most studies on the relationship between the built environment and traffic safety support the following framework: the built environment, including development patterns and roadway design, influences accident frequency and severity through its effect on the volume and speed of vehicle traffic (Ewing & Dumbaugh, 2009). For instance, a district with a higher population density tends to attract both more vehicular and pedestrian activities, which in turn likely increases the number of potential conflicts, and therefore, the number of traffic accidents.

On the other hand, pedestrian fatality risk tends to be higher on wider streets that allow higher vehicle speed (Gårder, 2004; Rosen et al., 2011). Micro-scale design elements (e.g., traffic calming measures such as curb extensions, and raised crosswalks) potentially reduce traffic accidents and injuries by reducing traffic volume and speed as well as reducing pedestrian exposure to traffic in the roadway (Bunn et al., 2009; Herrstedt, 1992). Neighborhood-level urban form and land use characteristics also affect actual traffic accident rates: high population density, commercial uses, transit access, cross-street density, liquor license outlet density, and major streets are positively associated with vehicle-pedestrian crashes (Clifton & Kreamer-Fults, 2007; Hess et al., 2004; LaScala et al., 2000, 2001; Sebert Kuhlmann et al., 2009). Therefore, strategies that encourage densification, mixed land use, and public transit use may enlarge the total number of injured pedestrians, indirectly, through increasing pedestrian activities (Miranda-Moreno et al., 2011).

In terms of the safety effects on older adults' walking, once more the analysis finds inconsistent evidence. Booth et al. (2000) find a correlation between perceived safety of walking and older adults' walking activities, while other studies find no such associations (King et al., 2000; Nagel et al., 2008). Using a composite perceived safety measure, Cao et al. (2010) find a negative association between perceived safety and walking, an unexpected result which they interpret as meaning that inactive older suburban adults tend to regard their neighborhoods as safer than urban neighborhoods. The results also vary depending on the dimension of safety considered. Balfour and Kaplan (2002), for example, examining physical activity, find no relationship with traffic safety, but a negative effect of inadequate lighting. King et al. (2000) also report that the effects of traffic, streetlights, and high crime are not significant, but unattended dogs are significantly associated with decreased physical activities. With particular emphasis on traffic safety, Hall and McAuley (2010) identify a significant difference in perceived pedestrian and traffic safety between active and inactive walking groups.

Finally, something akin to a network economy effect may exist: "safety in numbers," the idea being that as the number of pedestrians increases drivers become more aware of, and more cautious towards, pedestrians. Safety in numbers would imply that safety results, non-linearly, from pedestrian volume (which may, in turn, be influenced by the environment) (Elvik, 2009; Jacobsen, 2003; Leden, 2002; Wier et al., 2009). Analytically, however, the safety in numbers hypothesis faces empirical and theoretical challenges, related to: confounding factors (e.g., intersection countermeasures), which may lead to false association between accident frequency and pedestrian volume; potentially reversed causality, by which safer conditions result in greater pedestrian volume, and not vice versa; and weak theoretical mechanisms. Finally, in assessing potential tradeoffs between the health benefits of "active travel" and the increased risks implied, the increased physical vulnerability of older adults should not be ignored. Older adults tend to be more seriously injured when involved in traffic accidents, although they are also more cautious than other age groups (Zegeer et al., 1996; Harrell, 1991). The simultaneous deterioration of perceptual, cognitive, and physical abilities increases the fatality rate of older adults (Gorrie et al., 2008; Oxley et al., 2006). Older adults also tend to be exposed to the risk of higher crosswalk crash rates (Zegeer et al., 2005). Leden et al. (2006) find that sufficient visibility, orientation, and clarity improve older adults' safety while crossing streets.

4.2.2. Analytical Challenges

Self-Selection

As discussed in Chapter 3, the built environment-human behavior research realm faces the typical causality challenge: observing cross-sectional statistical relationships can only show correlation. Ideally, we would want a truly "randomized" experimental design, randomly distributing individuals into "treatment" and "control" settings and then comparing the behaviors of interest. Otherwise, we face threats to valid causal inference, particularly a challenge which in the built environment-travel behavior literature is now commonly referred to as self-selection (Mokhtarian & Cao, 2008).

Structural equation modeling (SEM) offers one analytical technique to control for self-selection, particularly when measures of individuals' relevant attitudes and preferences can be explicitly incorporated into the models. Full structural equation modeling simultaneously estimates measurement models, which extract latent variables (e.g., psychological constructs) from measured indicators (e.g., attitudes), and the structural models, which account for relationships among latent and observable variables (Golob, 2003). Therefore, SEM can help mitigate the self-selection challenge by enabling the consistent incorporation of attitudes and preferences in behavioral models and capturing complex influences between the built environment, attitudes, and travel behavior (Mokhtarian & Cao, 2008).

An increasing number of studies have turned to SEM to investigate the complex relationships between the built environment and travel behavior with controls for self-selection. Nonetheless, most suffer from limitations. Some do not explicitly include attitudinal variables in the SEM models (Abreu & Goulias, 2009; Liu & Shen, 2011), which weakens the self-selection control. Other analyses incorporate attitudinal variables, but not with complete SEM; extracting latent variables as fitted values of factor analysis on indicators, rather than simultaneously estimating the structural and measurement equations (Cao et al., 2007; Bagley & Mokhtarian, 2002). The analysis in Chapter 3 employed full SEM – incorporating attitudes and residential choice, to control for self-selection and to account for direct and indirect effects among exogenous and endogenous variables – to study baby boomers' travel behavior in suburban Boston. This chapter follows a similar approach.

Modifiable Aerial Unit Problem (MAUP)

Another challenge is how we should define boundaries of neighborhoods. This boundary effect of measurement, formally known as the modifiable area unit problem (MAUP), may significantly influence the results of spatial studies. The MAUP can be understood in two ways: scale and zoning. When lower-level data is aggregated into upper-level units, the scale effect masks variations within upper-level units. For example, within a traffic analysis zone (TAZ), there could be many different people with respect to their behavior and preferences. However, once aggregated into a TAZ, their differences are averaged as one value, which can critically differ from individual values.

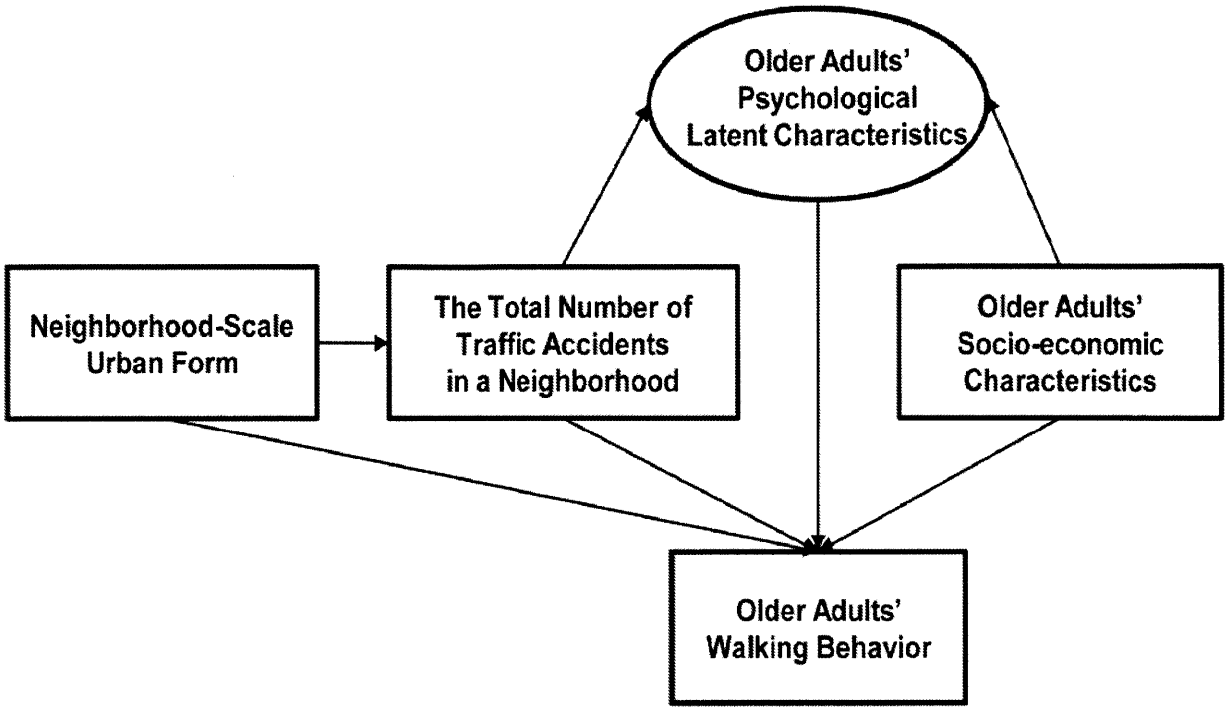
On the other hand, the zoning effect emerges as a result of spatial partitioning of each area. For instance, one unit may include a homogeneous residential use or mixed uses, depending on the shape of the boundary. Therefore, spatial partitioning is likely to determine the characteristics of a unit. This issue has been surprisingly under-studied in the travel behavior-built environment field, although some researchers have identified its potential effects; the magnitudes, signs, and statistical significances of coefficients are sensitive to the scale of aerial units (Hoehner, Ramirez, Elliott, Handy, & Brownson, 2005; Zhang & Kukadia, 2005). Thus, the best approach might be to maximize a level of data-disaggregation.

In order to minimize the modifiable area unit problem, this analysis collects individual-level neighborhood characteristics data at a highly-disaggregated scale (400m network buffer from a respondents' address). This approach also matches behavioral outcomes of interest (walking/biking and visiting neighbors) to a neighborhood boundary, assuming that neighborhood characteristics within 400m from a home influences local behavior.

4.2.3. Conceptual Framework and Research Questions

The diagram in Figure 4-1 depicts the conceptual framework relating neighborhood-scale urban form, traffic accidents, socio-economic/psychological characteristics, and older adults' walking behavior. Neighborhood-level urban form elements – measured by land use, transit supply, and road network characteristics – are expected to influence traffic accident frequency and baby boomers' walking behavior. Traffic accidents in a neighborhood, measured by the total number of annual traffic accidents, are also expected to affect walking behavior and latent psychological characteristics, including safety concern and social norms supporting walking. Hence, an indirect behavioral effect is anticipated: urban form influencing traffic accidents and traffic accidents influencing walk behavior.

Figure 4-1. Conceptual Framework: Older Adults Walking Behavior and the Role of Urban Form and Traffic Safety



Do neighborhood physical characteristics influence traffic accidents? Neighborhood characteristics, such as density, mixed use, accessibility to destinations and transit, and traffic speed, are likely to influence the total number of traffic accidents by increasing traffic speed and volume, as well as pedestrian volume. Clusters of traffic accidents are expected in locations with characteristics that attract more motor vehicle and pedestrian activities. The spatial distribution of traffic accidents logically leads to the second question.

Do neighborhood characteristics and safety causally affect baby boomers' walking behavior? It is anticipated that a neighborhood's physical characteristics influence residents' utilitarian and recreational walking behavior by determining the total number, relative quality, and distribution of potential destinations (e.g., recreation, friends) and the relative travel costs (both actual, including time and money, and perceived, including comfort, safety, and relative enjoyment). With regard to neighborhood safety, it is hypothesized that better actual safety levels improve perceived safety levels and reduce safety concerns, thus encouraging walking. A neighborhood's physical characteristics may, then, directly and indirectly influence baby boomers' walking behavior.

4.3. Research Context and Design

The study area includes urban neighborhoods in four cities from the Boston metropolitan area: Boston, Cambridge, Somerville, and Brookline. One of the oldest cities in the United States, Boston, and its immediately surrounding cities, exhibits diverse urban forms, with a range of building types, street patterns, and land use configurations. While it has a relatively well-developed public transportation system compared to other metropolitan areas in the US, Boston's levels of public transportation service still vary considerably across the urban area. Hence, the urban setting alone offers a reasonably heterogeneous context in which to examine how the built environment influences baby boomers' travel behavior.

4.3.1 Survey Design and Data

A mail-back survey, administered in October 2010, collected socio-economic and behavioral information on 55-to-65-year-old baby boomers. The sampling frame was mailing addresses (purchased from USAData, a commercial data vendor) for residents, 55 and older, of urban neighborhoods in the Boston metropolitan area. From the sampling frame, 7,000 households were randomly sampled. Those households received a mail-back household survey, including two booklets per household. The information collected through the survey included: (1) socioeconomic and demographic characteristics, (2) weekly behavioral characteristics (trip frequency by travel modes, purposes, and social activities), (3) travel and residential choice-related attitudes and preferences, and (4) levels of residential satisfaction

(Appendix, Figure 4A-1 and 4A-2). The survey instrument was specifically designed to include psychological factors, to enable the inclusion of latent characteristics via full SEM to help control for self-selection.

In total, 1,005 households, including 1,401 individuals, returned completed survey booklets, yielding a 14.4 percent response rate. To focus on the age cohort of interest, respondents younger than 55 or older than 64 are excluded. The final data include 933 baby boomers from 745 households. In comparison to the study presented in Chapter 3, where the mail-back household survey for suburban baby boomers, including a $5 non-contingent cash incentive, yielded a 23.6 percent response rate, this mail-back household survey without a cash incentive achieved a lower response rate by 9.2 percent point (14.4 percent).

MassDOT Highway Division provided motor vehicle accident data for three years (2006-2008).[1] Approximately, 82 percent of available accidents were successfully geocoded, based on XY coordinates or addresses. The remaining records had inadequate location information. Spatial data, including building footprints and heights, roads, parcels, land use, and transportation systems, come from MassGIS.[2]

4.3.2. Measures and Descriptive Statistics

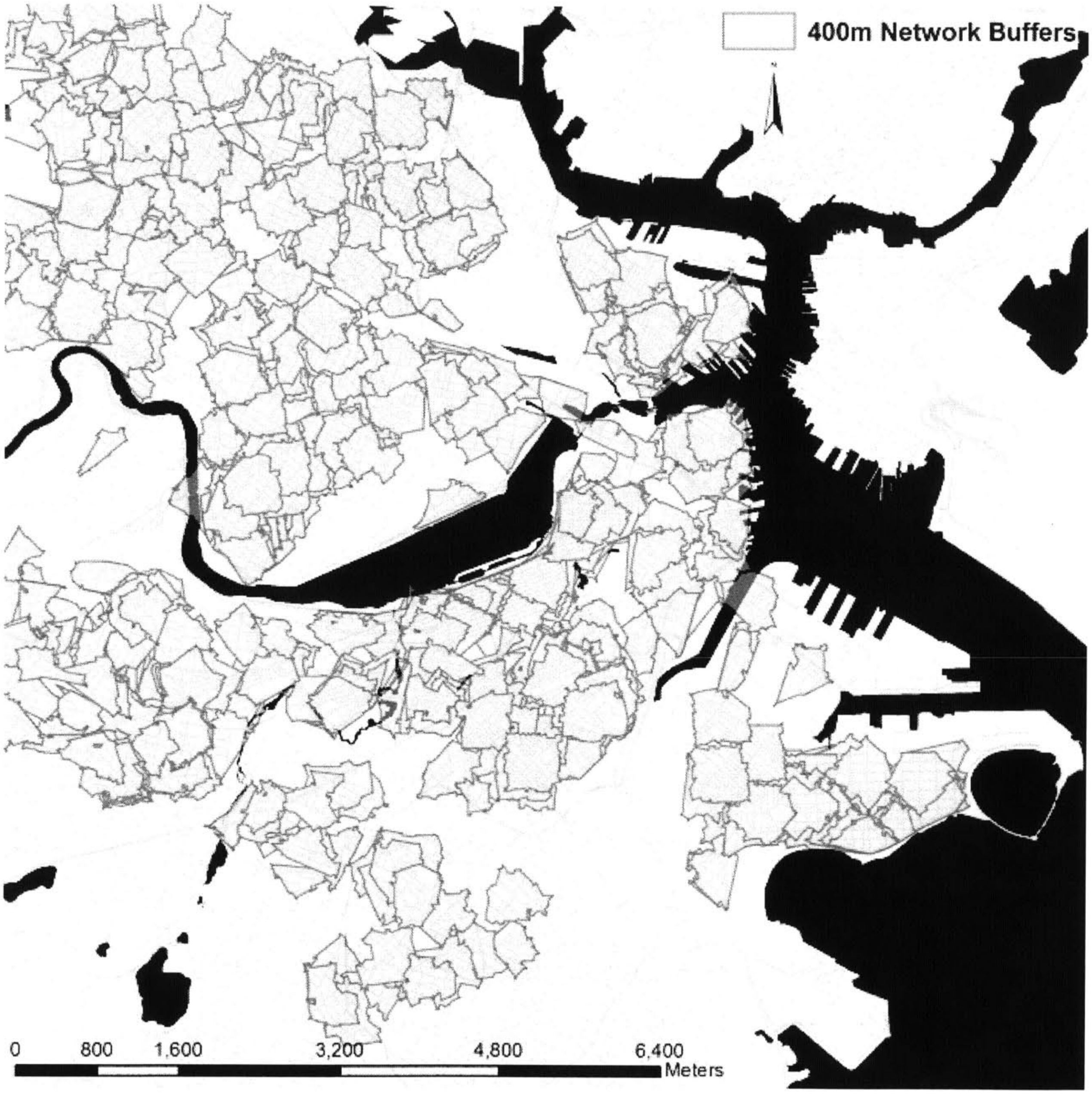
Table 4-1 presents variable definitions and descriptive statistics. Survey respondents reported the frequencies of "utilitarian" and "recreational" walking over the past week. The frequency of utilitarian walking is relatively evenly distributed. The distribution of recreational walking, on the other hand, is skewed, with 28 percent of individuals reporting zero recreational walking (hereafter referred to these as "non-active"). Overall, urban baby boomers' walking levels are higher, relative to the average NMT trips of suburban baby boomers (Table 3-2). Many baby boomers in the sample are wealthy: 42 percent is in the high income category. They are also generally healthy: only 6 percent reported a health condition that may prevent walking activities. Their car and bike ownership rates, as well as employment rate, are

[1] http://www.mhd.state.ma.us/default.asp?pgid=content/traffic/crashrateeval&sid=about.
[2] http://www.mass.gov/mgis/massgis.htm.

relatively high.

The analysis includes the six psychological indicators (Utilitarian Risk, Recreational Risk, Injury Concern, Accident Concern, Should Walk, and Support Walking), selected through exploratory principal component analysis (Appendix, Table A-7) and confirmatory factor analysis (Appendix, Table A-8). These indicators are based on Ajzen's (1991) theory of planned behavior. Utilitarian Risk and Recreational Risk represent individuals' *attitude* that is the subjective evaluation of the behavior. The high mean values of the two indicators identify baby boomers' concern about safety of walking. However, they tend to be confident about walking, despite the potential risk of walking: the mean values of Injury Concern and Accident Concern, which represent *perceived behavioral control*, are generally low. The high mean values of Should Walk and Support Walking indicate relatively strong influence of *social norms*. To summarize, urban baby boomers in the sample tend to be influence by social norms that support walking and feel confident about walking. This partially explains the relatively high utilitarian and recreational walking levels. However, they recognize the risk associated with outdoor walking activities. From the indicators, confirmatory factor analysis identified two latent variables: Safety Concern regarding injury and accidents during walking, and Supportive Social Norms that encourage walking. This latent structure enters the SEM as a measurement model.

Figure 4-2. 400m Network Buffers based on the Geocoded Addresses of Respondents



Measures of Neighborhood Characteristics

Neighborhood characteristics are expected to influence baby boomers' walking behavior, based on the assumption that only physical characteristics within a certain walking distance of the household location affect baby boomers' walking behavior. Neighborhood boundaries are defined via 400 meter network buffers derived from walking paths along streets, rather than a buffer based on a straight line radius emanating from the household. The street network used is based on the roads data from MassGIS, excluding highways, since the focus is on pedestrians. Then, 400m network buffers for each household are generated to represent the respective neighborhood (see Figure 4-2) and measure the physical characteristics and traffic accidents within each household's neighborhood. After generating the network buffers, individual addresses are eliminated to ensure anonymity. This approach can minimize the effects of the MAUP and test the scale effect of neighborhood boundary on local behavior.

Relevant physical characteristics are objectively measured with each of the buffers. Measures of urban form are categorized into 5Ds (Cervero et al., 2009): Density, Diversity, Design, accessibility to Destination, and Distance to public transit. Average values of estimated traffic volume and speed limit are also calculated for each of the buffers.

Density: Typical measurements of density are population per acre and job per acre. However, these measures are in fact proxies for urban form. Instead, this analysis uses a floor area ratio (FAR) that allows us to assess the effect of actual volumes of buildings on travel behavior. It is useful to distinguish "net density" from "gross density": net density includes only parcels, whereas gross density takes into account public spaces, for example sidewalks and parks. A net floor area ratio (FAR) measure, which represents the amount of built activity space, approximates the intensity of activities. This analysis uses net density, since other measures account for influences of open spaces:

Net Density (FAR) = total floor area / total parcel area

Diversity: Following Rajamani (2003), a measure of the mix of local land uses is calculated relative to an equal distribution of six land uses: residential, commercial, industrial, office, social/institutional, and leisure/recreational. Thus, the diversity index (DI) is expressed as:

$$DI = 1 - \left\{ \frac{\left|\frac{r}{T} - \frac{1}{6}\right| + \left|\frac{c}{T} - \frac{1}{6}\right| + \left|\frac{i}{T} - \frac{1}{6}\right| + \left|\frac{n}{T} - \frac{1}{6}\right| + \left|\frac{p}{T} - \frac{1}{6}\right| + \left|\frac{l}{T} - \frac{1}{6}\right|}{\frac{5}{3}} \right\},$$

where r = area in residential use (single and multifamily housing); c = area in commercial use; i = area in industrial use; n = area in natural condition; p = area in public/institutional use; l = area in leisure/recreational use; and the total area, $T = r + c + i + n + p + l$. A value of 0 for this index means that the land in the area has a single use and a value of 1 indicates perfect mixing among the six uses.

Design: A variety of neighborhood design elements may influence local behavior and perceptions of environmental quality. Open space, walking/biking paths, and street connectivity, measured by intersection density (Dill, 2004), may promote recreational and physical activities:

(1) *Open space density* = the area of open space / the area of the buffer,

(2) *Trail length* = the length of paths (km) within a buffer, and

(3) *Intersection density* = the number of true intersections (three-way, four-way and more) / the area of the buffer (ha)

Topography (or specifically, hilliness), extracted from a digital elevation model, could influence both walking behavior (more energy required) and traffic safety (more dangerous terrain):

Hilliness = the average slope (percent rise)

Access to Potential Destinations: Gravity-based measurements estimate the accessibility of an origin to all potential destinations, assuming smaller and more distant opportunities exert smaller influences by incorporating time with a decay function. The gravity-based walk accessibility combines land use (destinations) and transportation (distance) components:

Accessibility to Retail: $A_i = \sum_{i=1}^{J} [\exp(-b \cdot TT_{ij}) * 0.01]$,

where i = origins (individual addresses); j = potential destinations; TT = walking time (minutes, based on network distance) from i to j; b = travel distance sensitivity parameter.

Access to Subway: Walking accessibility to urban rail stations is estimated using the following gravity-based measure:

Accessibility to Transit: $AT_i = \sum_{i=1}^{T} [\exp(-b \cdot TT_{it})]$

Speed Limit: Higher average traffic speed represents potentially higher traffic risk and greater pedestrian discomfort. Average speed is determined based on the posted speed limits of roads within each network buffer.

AM Traffic Volume: Traffic volume reflects the level of exposure to traffic risk, which is measured as the number of vehicle trips passing through a neighborhood during AM peak time (2 hours). The traffic volume data come from the trip assignment stage of a 4-step transportation model calibrated for Boston.[3]

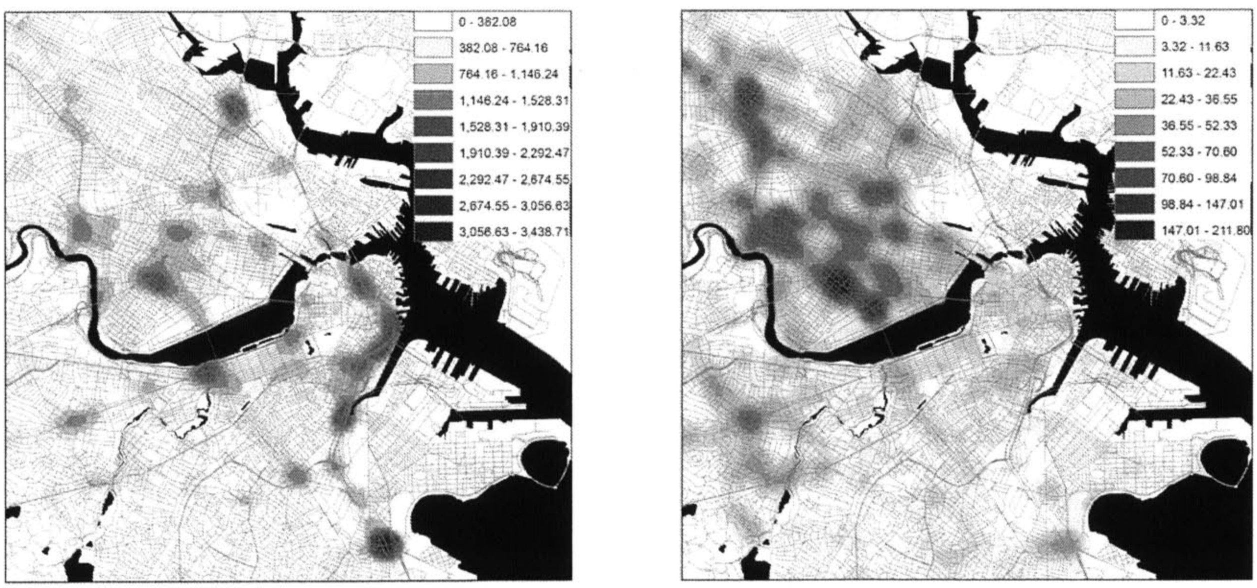
Traffic Accidents: The level of traffic accident frequency is measured as average annual traffic accident counts (averaged over 2006-2008) occurring within each 400m buffer (as geocoded from the available data). Figure 4-3a shows a kernel density map of all traffic accidents and Figure 4-3b shows those

[3] Vignesh Krishnamurthy provided these model run estimates.

accidents involving pedestrian accidents (as subset of all accidents). The pedestrian accident data reflect likely inconsistent reporting, across space, not surprising given the jurisdictional variation in reporting (across cities and across police jurisdictions within cities). This result is consistent with my own knowledge of traffic accident reporting in the area and confirmed by conversations with public health experts and city officials.[4] A kernel density map of all traffic accidents (Figure 4-3a) shows several hotspots along highways (I-93 and Storrow Drive), major roads (e.g., Massachusetts Avenue) and activity centers (e.g., Harvard Square, Central Square, and Coolidge Corner). This distribution foreshadows a positive association between traffic accidents and walkable neighborhood characteristics.

Figure 4-3. Kernel Density Maps of Traffic Accidents.

(a) Total Traffic Accidents **(b) Pedestrian-Vehicle Accident**



[4] The pedestrian-vehicle collision data from MassDOT apparently under-report accidents involving pedestrians in Boston. As a consequence, the pedestrian-vehicle accident rate in Cambridge is much higher than in Boston (see Figure 2b), which is unlikely considering downtown Boston's high levels of vehicular and pedestrian movements.

Table 4-1. Definitions and Descriptive Statistics of Variables (N= 914)

Variables		Mean	SD	Min	Max
Endogenous Variables					
Utilitarian Walking	During the past seven days, how many times did you walk for going to work, shopping, eating, errand, etc?	6.99	5.12	0	24
Recreational Walking	During the past seven days, how many times did you walk for exercise or a stroll in your neighborhood	3.49	3.60	0	12
	Ratio of individuals reporting *zero* recreational walking over past week (i.e., "non-active)	0.28*	-	-	-
Traffic Accident	Average of the total numbers of traffic accidents in 2006, 2007, and 2008	30.60	21.30	0.00	119.0
Neighborhood Characteristics					
Net FAR	Net floor-area-ratio	2.92	1.68	0.95	15.30
Land Use Diversity	Land use diversity index	0.29	0.13	0.00	0.74
Intersection Density	True intersection density (True intersections / ha)	1.55	0.49	0.00	3.53
Open Space Density	Percentage of open space	6.07	6.87	0.00	58.20
Trail Length	Total street length of trails and walking paths (km)	0.07	0.16	0.00	1.07
Hilliness	Percentage increase	1.19	1.10	0.00	7.52
Accessibility to Retail	Gravity-based accessibility to retail shops	0.10	0.13	0.00	1.35
Accessibility to Transit	Gravity-based accessibility to T-stations (Subway)	0.07	0.19	0.00	1.56
Speed Limit	Average speed limit of roads (km/h)	32.30	4.55	23.60	49.90
AM Traffic Volume	Estimated AM Traffic Volume (1000 vehicles / 3 hours)	31.46	20.43	0.30	116.4
Socio-Economic Characteristics					
High-Income	HH income (> $100k) (0. Otherwise, 1. High)	0.42	-	0	1
Mid-Income	HH income ($50k- 99.9k) (0. Otherwise, 1. Medium)	0.41	-	0	1
Low-Income (base)	HH income (< 49.9k) (0. Otherwise, 1. Low)	0.17	-	0	1
Disability	Health status (0. Unhealthy, 1. Healthy)	0.06	-	0	1
Employ	Employment status (0. Unemployed, 1. Employed)	0.68	-	0	1
Male	Gender (0. Female, 1. Male)	0.41	-	0	1
Own a Dog	Dog in a household (0. None, 1. More than one dogs)	0.12	-	0	1
Own a Bike	Bikes in a household (0. None, 1. More than one bikes)	0.53	-	0	1
Own a Car	Cars in a household (0. None, 1. More than one cars)	0.79	-	0	1
Psychological Indicators (Five-point Likert Scale)					
Utilitarian Risk	For me, the experience of walking to get to shopping or errands would overall be: (safe: 1 2 3 4 5 :unsafe)	4.54	0.81	1	5
Recreational Risk	For me, the experience of walking to get to shopping or errands would overall be: (safe: 1 2 3 4 5 :unsafe)	4.50	0.82	1	5
Injury Concern	If I wanted to walk, I am unlikely to do it because I am concerned about falling or injuring myself.	1.42	0.93	1	5
Accident Concern	If I wanted to walk, I am unlikely to do it because I am concerned about being in an accident with cars.	1.37	0.81	1	5
Should Walk	Most people who are important to me think that I should walk.	4.10	1.17	1	5
Support Walking	Most people who are important to me would support me if I chose to walk rather than to drive.	4.42	0.94	1	5

Note: *: 253 individuals reported *zero* recreational walking; - : indicates not applicable.

4.3.3. Methods

As mentioned above, full structural equation modeling (SEM) estimates multiple effects among a large set of exogenous and endogenous variables, while consistently incorporating latent variables to control for self-selection. SEM can capture direct and indirect effects – the latter representing the product of effects on the two variables and the intervening variables. The total effect between the two variables is the sum of the direct and indirect effects (Golob, 2003). SEM is used – described with the path diagrams and equations in Figure 4-4 – to account for the complex relationships between exogenous variables (neighborhood and socio-economic characteristics) and endogenous variables (traffic accidents, utilitarian walking, and recreational walking). SEM estimates two different models, for utilitarian and recreational walking, since these two walking behaviors have different motivations and may be sensitive in different ways to environmental and psychological conditions.

The dependent variables, utilitarian walking and recreational walking, measure the reported count of respective weekly walking trips. The variables have different distributions, with recreational walking having a large share of zeros reported. A negative binomial model estimates utilitarian walking (Figure 4-4, Eq. 2). For recreational walking trips, the large share of zero-reported trips (28 percent; see Table 4-1) indicates censoring, such that ordinary count models may be inappropriate (Jones, 2005). Thus, a zero-inflated model is used for recreational walking, combining a binary logit model to estimate the likelihood of being in a non-active (*zero* walking), as opposed to active, group and a count model, which weights the zeros based on the likelihood of being non-active as estimated in the logit model (Figure 4-4, Eqs. 1–3).[5] The zero-inflated model yields two sets of coefficients. The logit model estimates the effect of each variable on the probability of being in the non-active group; negative coefficients indicate a higher probability of being in the active group. The count model estimates the effect of each variable on trip frequency; positive coefficients imply a higher frequency of recreational walking.

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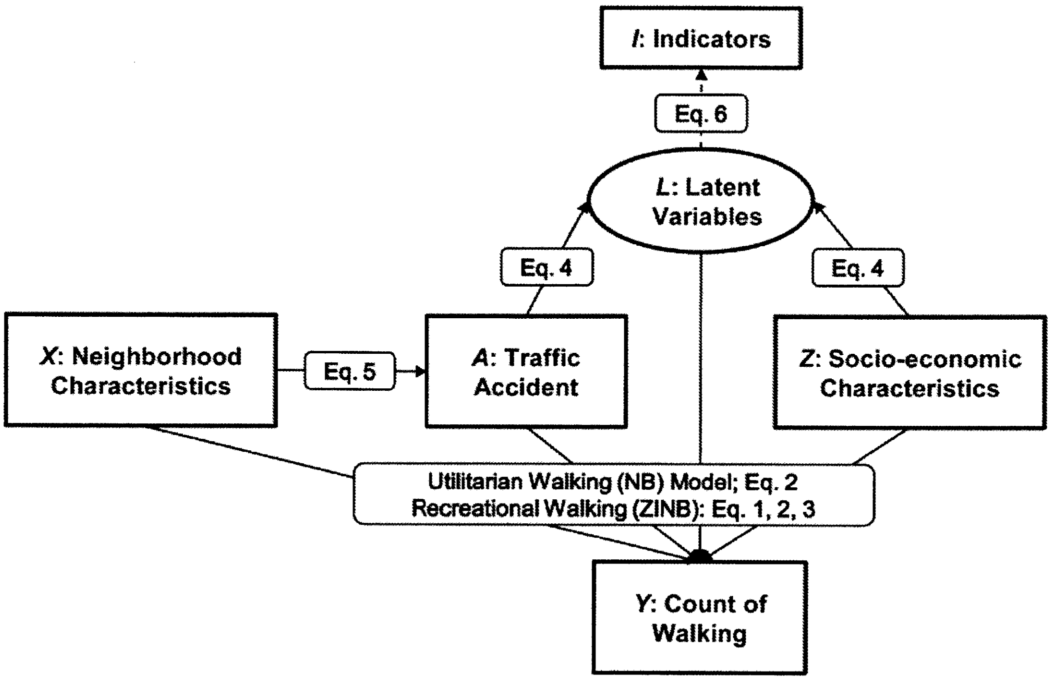
[5] As detailed in Chapter 3, these logit probabilities weight the zeros in the count model such that the probability of observing zero for an individual equals the probability of being non-active plus the probability of being active, multiplied by the probability of observing zero in the count model.

The count models are incorporated with measurement and structural equations in the SEM that control for self-selection, simultaneously incorporating latent variables. The SEM estimates the latent variables – extracted from the indicators in the measurement model (Figure 4-4, Eq. 6) – conditional upon socio-economic characteristics and traffic accidents (Figure 4-4, Eq. 4). The model also includes effects of neighborhood characteristics on the traffic accident level (Figure 4-4, Eq. 5). Thus, walking behavior, traffic accidents, and latent variables are endogenous, while socio-economic status and neighborhood physical characteristics are exogenous. These models are estimated in Mplus 5.0, using a maximum likelihood estimator with robust standard errors that are robust to non-normality and adjusted to account for non-independence of observations (i.e., respondents from the same household) (Muthen & Muthen, 2004, 2007). The dataset contains a clustering structure: some individuals are nested in households. Thus, it is necessary to account for potential correlation of behavior among same-household individuals (i.e., intra-class correlation), which may influence standard errors in the model results. The "cluster" option in Mplus, which uses a sandwich estimator, corrects standard errors. Mplus codes for the utilitarian walking model are available in the Appendix, Table A-16.

Figure 4-4. Path Diagrams and Equations of Structural Equation Models Estimating Relationships among the Built Environment, Traffic Safety, and Travel Behavior



Zero-Inflated Negative Binomial (ZINB) Model

Logit Model: (Eq. 1)

$\text{Logit}(\mu{=}0) = X\beta + Z\gamma + L\rho + \varepsilon$

$P(y_i = 0) = \pi = \frac{1}{e^{-(X\beta+Z\gamma+L\rho)}}, \; y_i = 0, 1, 2, 3, \ldots$

Negative Binomial Model (NB): (Eq. 2)

$\ln Y = X_{nb}\beta_{nb} + Z_{nb}\gamma_{nb} + L_{nb}\rho_{nb} + \zeta$

$P(y_i | x_{nb,i}, z_{nb,i}, l_{nb,i}) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!}, \; y_i = 0, 1, 2, 3, \ldots$

$E(y_i | x_{nb,i}, z_{nb,i}, l_{nb,i}) = \mu_i = e^{(x_{nb}\beta_{nb} + z_{nb}\gamma_{nb} + Y_{nb}\rho_{nb})}$

$V(y_i | x_{nb,i}, z_{nb,i}, l_{nb,i}) = \mu_i(1 + \alpha\mu_i)$

Combining the logit and NB models: (Eq. 3)

$P(y_i \mid x_i, z_i, y_i, x_{nb,i}, z_{nb,i}, y_{nb,i})$

$= \begin{cases} \pi + (1-\pi)\,P(0|x_{nb,i}, z_{nb,i}), & \text{if } y_i = 0 \\ (1-\pi)\,P(y_i|x_{nb,i}, z_{nb,i}), & \text{if } y_i > 0 \end{cases}$

X	Neighborhood Characteristics
Z	Socio-economic Characteristics
L	Latent Variables
Y	Count of Walking
μ	Expected count
π	Probability of being in zero-count group
α	Variance (Dispersion) parameter
β, γ, ρ	Unknown parameters
ε, ζ	Random disturbance terms

Structural Equation Model (SEM)

Structural Model (Eq. 4)

$L = Z\eta + A\omega + \xi, \quad \xi \sim N(0, \psi_\xi \textit{ diagonal})$

Structural Model (Eq. 5)

$A = X\theta + \kappa, \quad \kappa \sim N(0, \iota_\kappa \textit{ diagonal})$

Measurement Model (Eq. 6)

$I = L\lambda + \delta, \quad \delta \sim N(0, \varphi_\delta \textit{ diagonal})$

A	Traffic Accident
X	Neighborhood Characteristics
Z	Socio-economic Characteristics
L	Latent Variables
I	Indicators of L
$\eta, \omega, \theta, \lambda$	Unknown parameters
ξ, κ, δ	Random disturbance term
ψ, ι, φ	Covariances of random disturbance term

4.4. Behavioral Modeling

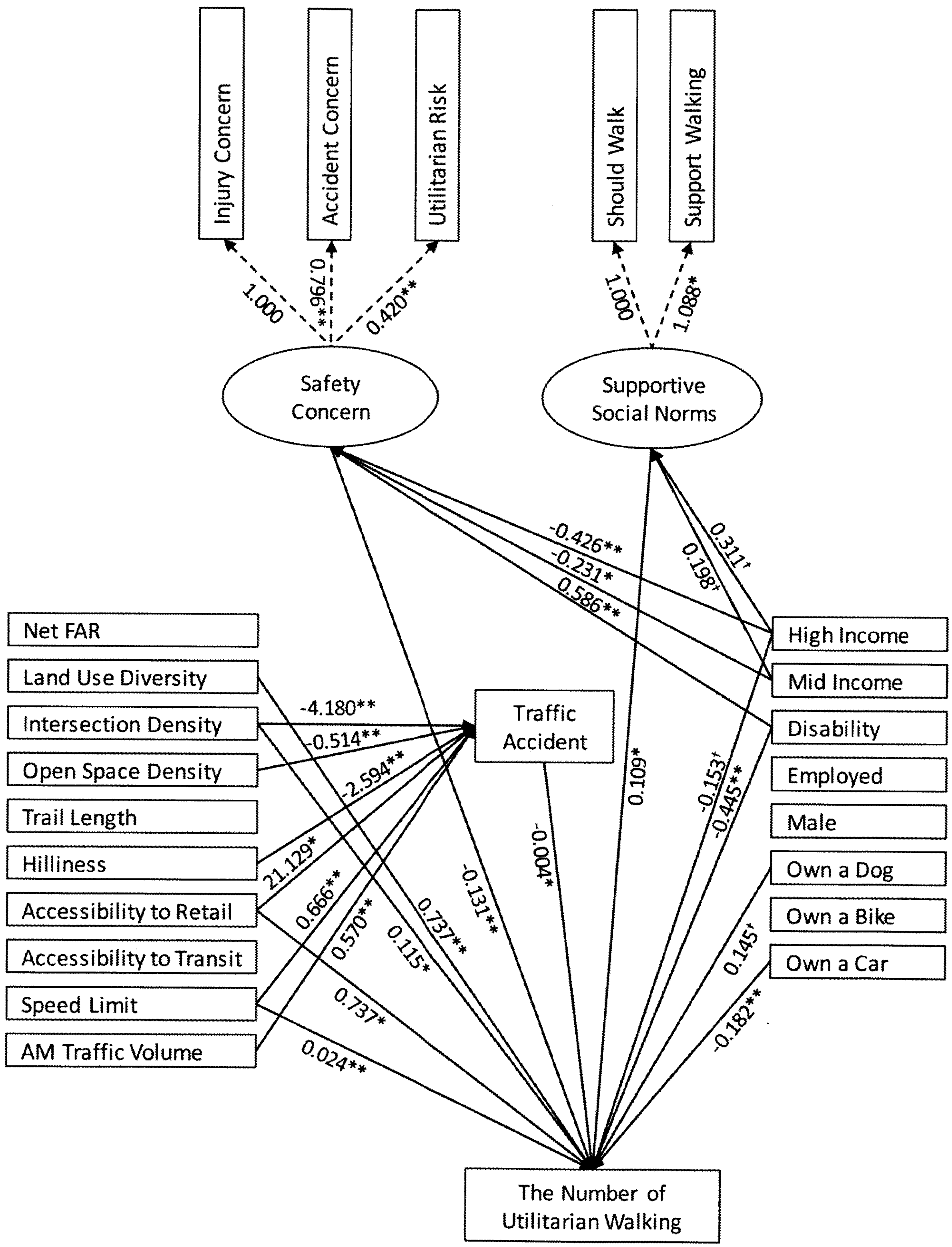
4.4.1. Utilitarian Walking

Figure 4-5 displays the significant effects from the utilitarian walking model results (full results are available in Appendix, Table A-9). The results confirm the spatial pattern of traffic accidents in Figure 4-3 and the first hypothesis that neighborhood characteristics are correlated with the number of traffic accidents. Accessibilities to retail shops, as well as speed limit and AM traffic volume, are associated with a larger number of traffic accidents. Neighborhoods with high intersection density, open space density, and hilliness tend to yield fewer traffic accidents, implying lower vehicle volume/speed or cautious driving in such areas. These neighborhood characteristics indirectly affect utilitarian walking via effects on traffic safety.

The results also support the second hypothesis regarding the negative effect of traffic accidents, as well as the direct effects of neighborhood characteristics on utilitarian walking. Higher average number of traffic accidents in a neighborhood significantly discourages baby boomers' walking. Neighborhood characteristics, such as land use diversity, intersection density, and accessibility to retail are significantly associated with higher utilitarian walking frequency. Speed limit is positively correlated with walking levels, a surprising result, possibly implying that utilitarian walking activities in a neighborhood are encouraged by major roads.

The direct, indirect, and total effects of neighborhood characteristics are presented in Table A-11 (see the Appendix). Better accessibility to retail and a higher share of major roads, represented by speed limit, indirectly discourage baby boomers' utilitarian walking through traffic safety effects, although they directly encourage walking. Among personal characteristics, baby boomers with disabilities or car owners are less likely to walk. The model also identified significant influences of psychological factors: Individuals with higher levels of safety concerns tend to walk less, while an individual's sense of social norms that support walking significantly encourages utilitarian walking.

Figure 4-5. Path Diagram and Results of the Utilitarian Walking Model



Note: † p<0.10, * p<0.05, ** p<0.01

4.4.2. Recreational Walking

A zero-inflated negative binomial (ZINB)[6] model for recreational walk trips estimates first the likelihood of being in the non-active group and then the number of recreational walk trips among the active group (Figure 4-6 and Appendix, Table A-10). The result indicates that higher traffic accident levels increase the likelihood of being in the non-active group. However, supportive social norms encourage baby boomers to be "active" (make at least one recreational walk trip per week). Neighborhood characteristics, net FAR, and land use diversity are positively correlated with recreational walking frequency. Regarding individuals, employed baby boomers tend to walk less, while dog owners are likely to walk for recreation more frequently. The model also detects indirect effects of accessibility to retail, traffic speed, and volume that discourage individuals from being in the active walking group (Appendix, Table A-12).

4.5. Implications

The models reveal the more complex inter-relationships between urban form, traffic safety and active travel for urban-dwelling baby boomers. "Walkable" neighborhoods, particularly those with good accessibility to retail, are correlated with more traffic accidents (and higher pedestrian risks), effects which indirectly discourage utilitarian and recreational walking. These countervailing effects are consistent with those discussed in previous studies (Miranda-Moreno et al., 2011; Moudon et al., 2011). The findings also suggest the need for examining more closely the causality implied in the "safety in numbers" argument (i.e., a larger number of pedestrians leads to improved safety levels). The utilitarian walk model shows that higher traffic accident frequency decreases baby boomers' walking. In other words, baby boomers are likely to participate in more walking activities in safer neighborhoods, implying a potential "numbers in safety" argument. Nonetheless, this result should be viewed tentatively because of lack of reliable traffic and pedestrian volume data.

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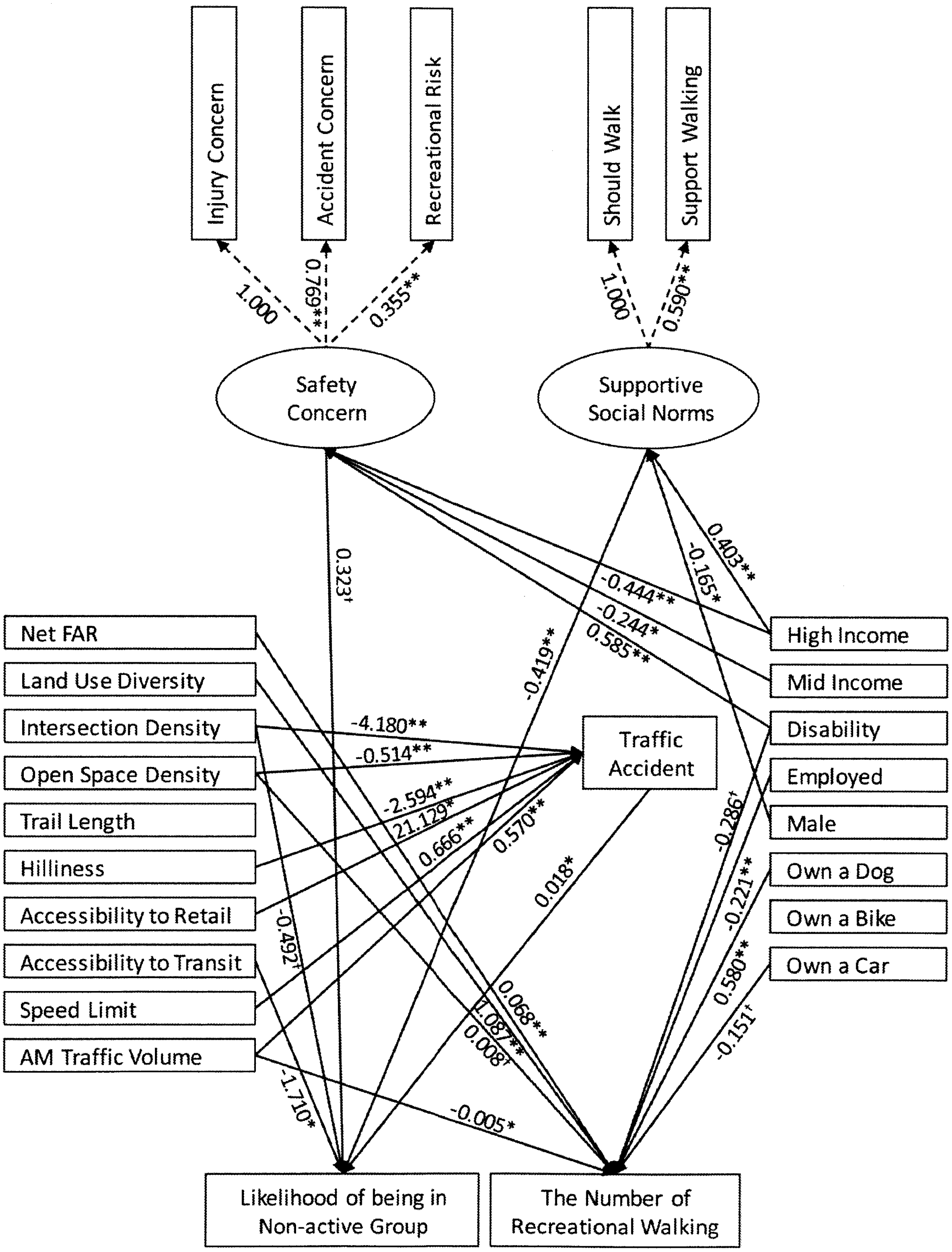
[6] The Vuong test indicates that ZINB is superior to a negative binomial, and a likelihood ratio test indicates ZINB is preferable to a zero-inflated Poisson.

Figure 4-6. Path Diagram and Results of the Recreational Walking Model



Note: † p<0.10, * p<0.05, ** p<0.01

The effect of social norms on utilitarian and recreational walking is consistent with previous findings that social support is associated with physical activity, particularly among older adults (Bauman & Bull, 2007). The result indicates that baby boomers' perceptions about neighborhood safety play a significant role in engaging in walking activity. That is, both physical and non-physical (e.g., social support for walking) interventions can contribute to increased activity levels of baby boomers. Nonetheless, despite the significant influence of latent variables, the analysis identifies little evidence of self-selection for utilitarian walking: the latent variables are not conditional upon safety from traffic, and the inclusion of latent variables does not discernibly change the signs, magnitudes, or significance levels of traffic accidents and other neighborhood characteristics. (see Appendix, Table A-13 and Table A-14 that include the model results without latent variables). This result is inconsistent with previous findings about the complex relationships between actual and perceived safety. Cho et al. (2009) find that higher actual risk of traffic accidents increases perceived risk. However, higher perceived risk is, in turn, negatively correlated with actual risk: people tend to perceive mixed-use areas with higher traffic accident rates as safer than single-use neighborhoods, due to lower expectation of injury severity (Cho et al., 2009; Schneider et al., 2004).

There are several potential causes for the non-significant association between actual traffic accidents and safety concern in the study. It may simply be the actual relationship in this particular context for this particular cohort. However, data and study design could cause the non-significant relationship. For example, the analysis still encompasses relatively homogeneous built urban environments, while previous studies examined urban and suburban neighborhoods. Also, as discussed previously, the traffic accident and exposure data are likely inaccurate.

4.5.1. Shortcomings and Future Research

As just mentioned, the analysis suffers from data quality issues. First, the results only apply directly to a specific demographic, geography, and time of year (i.e., October, 2010) and may not be generalizable.

Even for the specific groups and areas studied, the sampling procedure likely suffers from unknown biases that further limit validity and generalizability. In terms of contextual data, the traffic accident data are certainly inaccurate, as discussed, and using total traffic accidents, instead of pedestrian-vehicle collisions, may be problematic. More systematic, consistent data collection and validation procedures are necessary. In addition, the data do not include numerous potentially relevant micro-scale built environment measures, such as sidewalk conditions, roadway design, street crossing design, and traffic calming devices, which may influence pedestrian safety (Ewing & Dumbaugh, 2009; Zegeer et al., 2005). These omitted variables may be confounding the results (Bhatia & Wier, 2011), which warrants further investigation.

Analytically, despite the application of full SEM to strengthen causal inference, the cross-sectional, observational study design cannot overcome its fundamental limitation: being unable to capture behavioral changes corresponding to changing environments. Such an analysis would require an experimental design with longitudinal data. The cost of SEM modeling sophistication is the difficulty of revealing relative or marginal effects and constructing predictive models to estimate behavioral outcomes. Another analytical shortcoming is the inability to account for spatial dependency among individual observations. The spatial distributions of traffic accidents and behavioral outcomes suggest the existence of spatial autocorrelation, which can produce potential bias in the models. Potential spatial dependency is not accounted for in the models, due to the difficulty in combining SEM and spatial models, another area for future research.

4.6. Conclusion

The study sheds light on the countervailing effects of walkable urban environments on baby boomers' walking activities, analyzing behavioral data (utilitarian and recreational walking) from a mail-back survey and using objective built environment and traffic safety measures. The models find that walkable urban forms (mixed use, well-connected streets, and good access to potential destinations) directly encourage baby boomers' walking, but that higher traffic speed/volume and accessibility to retail are associated with frequent traffic accidents that, in turn, discourage walking.

The results suggest more cautious approaches may be necessary for designing urban spaces for walkability and also call into question prescriptions based on the "safety in numbers" hypothesis. Even if high accident incidence does not mean higher risk per person as "safety in numbers" would suggest, the absolute number of accidents is still high in walkable activity centers. Frequent accidents can lead baby boomers to hesitate to walk. Thus, the goal of planning and policy should be to minimize both the rate and absolute number of accidents, considering baby boomers' vulnerability to traffic accidents. If walkable neighborhood-scale planning and design interventions that seek to improve walkability can unintentionally increase overall exposure to traffic hazards, other actions should be considered to enhance pedestrian safety. Micro-scale designs (e.g., better crossing design and countermeasures) and speed regulations at activity centers (hot spots of accidents) may be promising approaches to complement neighborhood-level planning strategies, improving walkability and pedestrian safety simultaneously.

Latent psychological factors, although providing little evidence of self-selection in this study, do apparently influence baby boomers' walking: supportive socials norms encourage utilitarian walking and safety concerns reduce recreational walking. These findings suggest that educational or social programs to promote safe walking may coax baby boomers to engage in additional walking activities. Physical interventions that assure pedestrian safety and reduce anxiety about walking may also be effective. Overall, the study improves understanding of the complex relationships among the built environment, safety, and psychological characteristics that, together, influence baby boomers' walking behavior.

Chapter 5

Conclusions and Implications

5.1. Introduction

This dissertation has investigated baby boomers' travel and social behavior to answer a fundamental question: how do neighborhoods' design, social structure, and safety affect older adults' walking and social behavior? To answer this question, the three independent essays examined the influence of urban and suburban environments separately. The analyses identified different effects and significances of neighborhood characteristics between urban and suburban areas. In suburban areas, only proximity to potential destinations significantly influences recreational walking and biking trip frequency, while the effects of other neighborhood characteristics are insignificant. In contrast, many urban neighborhood characteristics significantly encourage walking behavior.

This chapter summarizes and concludes this dissertation, discussing the design and planning implications of those contrasting findings. The chapter is structured as follows: (1) the theoretical and analytical framework of the neighborhood effects; (2) the discussion of general strategies for aging-friendly neighborhoods; (3) the review of the three essays' findings, with a focus on neighborhood effects; (4) the urban and suburban comparison of neighborhood characteristics and travel behavior, (5) the implications for neighborhood design and planning for the aging population; and (6) the limitations of the research and future research directions.

5.2. Theoretical and Analytical Framework

The fundamental framework of the study is the docility hypothesis (Lawton, 1973). In Lawton's ecological model, aging tends to reduce physical, social, and economic strength of individuals (personal competence), which is likely to decrease relative independence from the demands of environmental qualities, such as distance to destinations and sidewalk conditions (environmental press). This would then suggest that the built environment would play an important role in maintaining older adults' active aging. Researchers from various fields have developed ecological models that emphasize the confluence of interpersonal, intrapersonal, environmental, and cultural factors. The ecological models posit that the combination of psychological, social, and environmental variables will best explain human behavior (Saelens, Sallis, & Frank, 2003; Sallis et al., 2006). Therefore, with the ecological model framework, researchers incorporate theories from the field of psychology, such as the theory of planned behavior (Giles-Corti & Donovan, 2002; King & Sallis, 2009) The theory of planned behavior attempts to explain behavioral outcomes with psychological factors: *intention, perceived behavioral control, attitudes,* and *subjective norms* (Ajzen, 1991).

"Net utility" theory also attempts to explain individual travel behavior with regard to the built environment (Maat et al., 2005), although its focus is not necessarily on older adults' behavior. According to this theory, people make decisions based on the expected utility of the trip (e.g., arrival at a destination) and the disutility of the trip (e.g., time and costs). The built environment affects individual travel behavior, by influencing the utility and disutility: it determines the relative location of potential destinations; the layout of street networks, which is related to trip distances and times; and density and diversity of land use that impact perceived times.

Based on these theories, the dissertation proposed conceptual frameworks that hypothesize the relationship among the built environment, baby boomers' local behavior, socio-demographic characteristics, psychological characteristics (attitudes and preferences), and safety (Figure 3-2 and Figure 4-1). In this framework, socio-demographics of individuals, community structure, as well as environmental characteristics (neighborhood design) influence behavioral patterns. These personal, community, and neighborhood characteristics are expected to indirectly affect baby boomers' local behavior, by shaping their travel attitudes and residential preferences. These psychological factors also play a role in determining local behavior. Lastly, levels of safety from traffic affect behavior, interacting with the built environment. This conceptual framework enabled empirical analyses that investigated the interrelated effects among the key factors.

5.3. General Strategies for Aging-friendly Neighborhoods

In the light of the theoretical framework, this section discusses promising strategies to build "aging-friendly" neighborhoods that satisfy older adults' environmental and social needs. The major systems of an aging-friendly community – housing, transportation, health, social interaction, cultural and religious involvement, educational and leisure opportunities – should be responsive to the needs and capabilities of older adults, so as to promote the physical and psychological well-being of aging residents (Scharlach 2009). The general strategies to meet environmental (transportation) needs can be categorized into three approaches: (1) a mobility-enhancing approach, (2) an accessibility-enhancing approach, and (3) an information and communication technology (ICT)-based approach.

Mobility-enhancing approach

First, older adults need improved transportation options, such as more public transit, improved roads and highway system, and available demand-responsive services, which enhance their mobility. Since many older adults will be driving until very late in their lives (Rosenbloom 1999), it is promising to modify the automobile-based systems and infrastructures, so as to make older adults' driving safer and more convenient. Driving education, targeting the needs and skills of older drivers, helps them to maintain necessary driving skills. For those who cannot afford to own vehicles, car-sharing programs can be an effective support, especially in age-segregated settings. Roads and highways can be made safer by improving street lighting, signage, and lane-marking, considering older adults' diminishing eyesight and physical sensitivity (Rosenbloom 2003). However, these driving-based approaches cannot address other problems associated with automobile use, for instance, air pollution and decreased physical activity level.

On the other hand, providing more frequent, diverse, reliable, and safe public transportation services can improve the mobility of older people. However, even improved public transit options are unlikely to sufficiently substitute for automobile use or satisfy the needs of older people who are unable to drive (Scharlach 2009). Research suggests that customized services, such as a higher level of driver assistance, some route deviation, flexible boarding and disembarking, and off-peak service can better meet older adults' needs (Burkhardt 2002). Paratransit services, especially dial-a-ride and community-based paratransit, may significantly enhance older adults' mobility (Cervero 1997). Dial-a-ride paratransit provides flexible, demand-responsive, and door-to-door services, which are particularly beneficial for minority groups, such as the disabled and the frail elderly. Community-based paratransit is the informal network of private cars and vans that provide transportation to major destinations around neighborhoods. Therefore, it can provide services for poor and minority neighborhoods with scarce public transit service and low vehicle ownership. However, paratransit inherently targets niche markets; its application will be limited in filling the gaps of automobile and public transit. Overall, the biggest challenge of mobility-enhancing strategies is their considerably higher costs than those of traditional systems. Therefore, sufficient subsidies and efforts to increase efficiency of the new systems are essential to implement mobility-enhancing strategies.

Accessibility-enhancing approach

The spatial distribution of uses and destinations is crucial for the well-being of older people, because they should be able to access amenities to satisfy their everyday needs. However, the predominant residential pattern in suburbs (i.e., low-density neighborhoods) makes it difficult for older adults to depend on travel modes other than automobile. Since their decreasing ability to drive can significantly limit accessibility to necessary destinations, there have been substantial discussions of land use strategies to enhance accessibility. One strategy is to relocate older adults to denser urban areas where accessible amenities and diverse transportation options are available. While this land use option is promising, many studies and surveys consistently show that older people in suburbs are unlikely to move to more walkable and transit-oriented neighborhoods (Stafford 2009). Even if some older suburbanites move to cities, the majority of them will continue to age in their current neighborhoods.

Another strategy is to create denser, transit-oriented, and mixed-use environments either by improving existing neighborhoods or by building new neighborhoods. For example, New Urbanism strategies, such as infill developments, diverse housing options, and improved pedestrian environments, can improve overall accessibility in neighborhoods and provide options for older people to move into denser and more mixed areas within their own neighborhoods. Some studies found that neighborhood design elements, such as the proximity to destinations, well-connected pedestrian pathways, and neighborhood attractiveness, affect older adults' travel patterns – more walking trips and less automobile use (Joseph and Zimring 2007; Cao, Mokhtarian, and Handy 2007; Michael, Green, and Farquhar 2006). Despite its promises, critics argue that the effects of New Urbanism approaches are marginal and cost-inefficient at best (Pickrell 1999). Furthermore, transit-oriented, denser neighborhoods are more likely to attract a younger population rather than older people (Bernick and Cervero 1997), and are therefore less effective in improving older adults' environments. Lastly, although gerontologists have argued that associability is essential to elderly well-being (Carp and Carp 1982; Carp 1988; Lawton 1980, 1980), a higher level of accessibility is not always beneficial to older adults. For example, while the proximity to activities and services is desirable in general, noise and crowdedness of the activities can be disturbing and provoke older adults, if they cannot protect themselves from the undesirable factors. Therefore, aging-friendly neighborhoods should provide not only accessibility but also controllability of accesses.

Information and communication technology (ICT)-based approach

ICT offers a new capacity to enhance transportation systems, as well as to manage health and improve safety. Regarding transportation systems, technological solutions on roads or in vehicles can make older adults' driving safer. Older drivers can better control their vehicles if cars warn drivers when other cars are driving too closely or their cars are about to hit objects on roads. Information technology can make dial-a-ride systems more cost-effective and time-competitive by integrating automated vehicle location, automated scheduling and routing, database systems, and user interface (Cervero 1997). Therefore, ICT can be specifically beneficial for older adults by making transportation systems more sensitive to their needs and skills.

While ICT can improve traditional mobility, it can also provide innovative services for the elderly. For instance, new "gerontechnologies," such as systems to monitor older adults' health and safety, interactive devices to remind them to regularly take their medicine, and everyday consumer devices to connect them to caregivers, are available. However, technological availability is necessary, yet not a sufficient condition: the real application of these gerontechnologies depends on a sustainable and profitable business model that encompasses service providers, caregivers, and appropriate regulation (Coughlin 2001). Moreover, other important questions have been raised: who will decide the adaptation of new technologies? How will the data be managed, and to whom will it be reported? (Coughlin 2006). Thus, research has identified a variety of older adults' concerns regarding the new technologies. Fundamentally, they are not fully convinced of the functionality, reliability, affordability, and usability of gerontechnologies. These concerns may be natural, when people are faced with new technologies. Another concern is that new technologies that monitor everyday life can threaten the privacy of older people. This issue is related to the question of who will manage the data and how much older people can trust database management. Moreover, specifically designed technologies for older adults may stigmatize them as a frail and dependent group. Therefore, in order for new technologies to contribute to the well-being of the elderly, it is crucial that other factors, such as profitable business models, reliable caregiver and service systems, as well as social consensus and psychological adaptation to the technologies, support technological innovations.

5.4. Summary of Findings: The Effects of Neighborhood Design

Among the strategies for "aging-friendly" neighborhoods, this dissertation has primarily focused on accessibility-based approaches. The morphological analysis in the first essay identified distinctive design features of age-restricted neighborhoods. Overall design elements of many age-restricted neighborhoods are coherently coordinated, including amenities, such as neighborhood open space, community centers, walking paths, and golf courses. Incentives by local governments – relaxed or waived requirements, including excessively wide right-of-way width, minimum lot size, and setbacks – facilitate diverse neighborhood designs that combine a mix of detached and attached single-family housing types, unconventional site configurations, and communal land ownership.

Despite the age-restricted design, distinguished from ordinary suburban development patterns, the locations of the age-restricted neighborhoods studied tend to be isolated, with few potential destinations and public transportation services within walking distance. The dwelling density of age-restricted neighborhoods seems to be higher, because of the clusters of units, including attached single-family housing. However, age-restricted neighborhoods' overall dwelling density, accounting for open public spaces, is not significantly higher than that of un-restricted neighborhoods. The road density of age-restricted neighborhoods is also not significantly higher than surrounding neighborhoods, implying that there is no difference in street connectivity between the two types. Not surprisingly, the Walk Scores of age-restricted neighborhoods remain in the lowest category (0-24: car-dependent: almost all errands require a car). This analysis indicates that the variation in suburban neighborhood design introduced by age-restricted neighborhoods is relatively small.

The second essay examined the causal effect of age-restricted neighborhoods on suburban baby boomers' recreational NMT and social trips, distinguishing community (age-restriction and associated aging-friendly social services) from physical (neighborhood design) influences. These communities increase the likelihood of boomers being active recreational walkers or bikers, as well as social trip-making. However, neighborhoods' physical characteristics generally have no effects on baby boomers' behavior: only better proximity to destinations tends to increase recreational NMT trip frequency.

In contrast, the third essay found that neighborhood characteristics in urban areas significantly affect baby boomers' utilitarian and recreational walking. The behavioral models find that mixed use, well-connected streets, and good access to potential destinations tend to encourage utilitarian walking. Also, higher density, mixed use, open space density, and better accessibility to public transportation are likely to promote recreational walking. However, the analysis identified countervailing effects through the level of traffic accident incidence. Overall, these findings indicate that, relative to suburban areas, urban areas include greater variations in neighborhood characteristics, which may influence walking activities.

5.5. Urban and Suburban Comparison

This dissertation has investigated urban and suburban neighborhoods separately. This chapter compares urban and suburban neighborhood characteristics and baby boomers travel behavior, in order to offer comprehensive view of neighborhood effects in the metropolitan area. "Urban" versus "suburban" is a popular categorization of human settlements in urban design and planning. As previous chapters discussed, the majority of baby boomers in the US reside in suburban or rural areas, while the reminder live in urban neighborhoods. This demographic geography raises a series of questions: what are the social implications of living in "urban" and "suburban" areas? How do urban environments differ from suburban characteristics? Does urban residents' travel behavior significantly differ from their suburban counterparts? This section attempts to identify the differences in neighborhood characteristics and baby boomers' travel behavior between urban and suburban areas using the two data used in Chapter 3 and 4.

Comparison of Urban and Suburban Neighborhoods

This section empirically compares the differences between urban and suburban neighborhood characteristics (see Figure 5-1). Since the analyses in Chapter 3 and 4 used different urban form measures, it is not possible to directly compare urban and suburban neighborhood characteristics. Thus, in this section several urban neighborhood characteristics are transformed into the same measures used for suburban neighborhoods. For example, the gravity-based accessibility to destinations in Chapter 4 is recoded in order to compute the percentage of urban neighborhoods that have at least one destination within 400m.

Figure 5-1. Urban and Suburban Study Areas

Table 5-1, including comparable neighborhood characteristics, shows that urban neighborhoods tend to have more well-connected street networks and better access to recreational facilities, potential destinations, and transportation services. The average intersection density of urban neighborhoods is approximately twice as high as that of suburban neighborhoods. While 92 percent of urban neighborhoods in the sample has nearby recreational facilities, including public open spaces and trails, only 35 percent of suburban neighborhoods has such amenities. The difference in the percentages of neighborhoods with at least one potential destination is also very large: 99 percent in urban areas versus 45 percent in suburban areas. Urban neighborhoods tend to have better access to rail systems: 79 percent of urban neighborhoods has subway stations, while 22 percent of suburban neighborhoods has commuter rail stations within 1km.

Table 5-1. Comparison of Urban and Suburban Neighborhood Characteristics

	Urban Neighborhoods (n=933)	Suburban Neighborhoods (n=458)	Mean Difference
Average Intersection Density (True intersections / 100m of streets)	0.66	0.32	0.34**
Percentage of neighborhoods with Recreational Amenities within 400m	92	35	57**
Percentage of neighborhoods with Destinations within 400m.	99	45	54**
Percentage of neighborhoods with Rail within 1km	79	22	57**

Notes: * $p<0.05$, ** $p<0.01$, indicating significance levels of difference of means/proportions

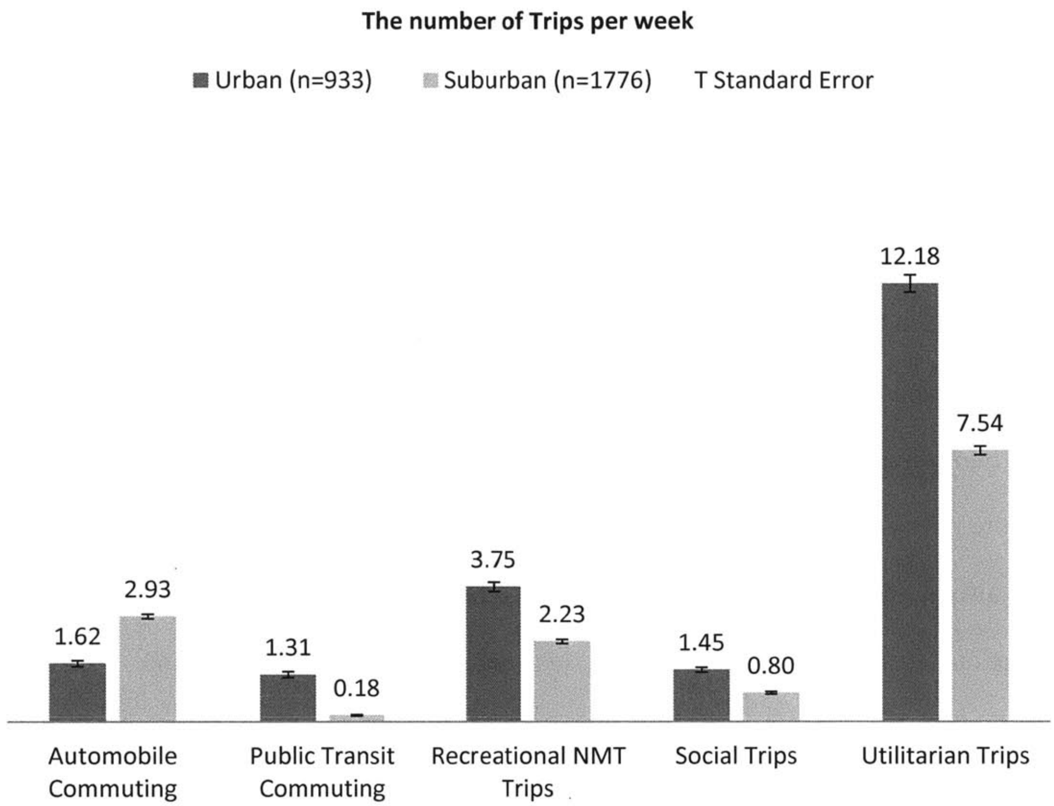
This comparison could be biased because of different data sources: for example, the urban destination data is from the ESRI Business Analyst Data, whereas suburban destination data is from Google Earth's "places of interest." Despite these potential sources of error, it is safe to say that urban neighborhoods tend to have more amenities, better street connectivity, more nearby destinations, and better access to public transportation than suburbs. These urban neighborhoods' characteristics are likely to encourage more active travel patterns, relative to suburban neighborhoods.

Comparison of Urban and Suburban Baby Boomers' Travel Behavior

To examine behavioral differences between the urban and suburban boomers, I combined the two mail-back household surveys used in Chapter 3 and 4. Five types of comparable trips were identified (Figure 5-2). Urban baby boomers tend to commute with their cars less than their suburban counterparts. The frequency of public transportation commuting in urban areas is higher than in suburban areas. Urban baby boomers are also more physically and socially active, making more NMT and social trips. The difference in utilitarian trips is also quite large, indicating urban baby boomers are more actively engaged in various events, such as going out for shopping, eating, banking, meeting a doctor, or doing an errand.

Despite these differences, it is uncertain whether these observed differences are induced by the neighborhood effects or self-selection of more actively inclined people in urban areas. However, it may be reasonable to assume at least partial effects of the built environment on baby boomers' activities, considering the relatively large urban-suburban difference in neighborhood characteristics. Advanced methods, for example a propensity score matching approach, would enhance this argument by controlling for potential differences of individual baby boomers in the sample.

Figure 5-2. Comparison of Urban and Suburban Baby Boomers' Travel Behavior



5.6. Planning and Policy Implications

This series of analyses – intra-suburban, intra-urban, and urban-suburban – sheds light on the effects of neighborhood environments on baby boomers' local behavior. The results should be discussed in light of the elderly neighborhood planning and policy context. In the US, the majority of baby boomers live in auto-dependent suburbia. Most older adults in suburbs prefer aging in place. This desire is manifested in the low moving rates and long-term occupancy of older households (Lipman, 2012). A survey by the American Association of Retired Persons (AARP) confirmed this desire: 90 percent of older households stated their preference for aging in their own homes as long as possible. This is because of older adults' attachment to their current homes or neighborhoods; their desire to live in familiar environments; and a lack of affordable, convenient, and attractive alternative housing options.

Given this strong preference for aging in place, broadly two planning and policy challenges for enabling independent and active aging emerge: how do we connect older residents to social services? And how do we modify and improve current housing and neighborhoods to satisfy changing needs of aging residents? Aging in place is not always possible for every older adult: some older adults may need to or want to relocate to aging-friendly planned communities that provide desirable services, such as assistance with riding, bathing, or dressing; medical services; and housekeeping services. This raises an important question: where and what types of elderly neighborhoods should we provide?

In this context, the findings suggest that, in general, interventions in neighborhood environments can encourage active behavioral patterns, especially in urban areas. Yet current environmental variation within suburbs, as manifested in age-restricted neighborhood design, tends to be too small to induce such behavioral changes. This implies that promoting desired behavioral outcomes requires quite large environmental changes: for example, relocation from suburbs to cities or radical improvement of density and diversity in suburbs may result in behavioral changes by baby boomers. However, most baby boomers prefer to stay where they are living now, as discussed above, although some evidence suggests that some of them may be inclined to return to urban settings as they get older (Wieckowski, 2010). Also, achieving urban-level density or diversity, as well as transportation service, in suburban areas is highly unlikely, given current zoning systems, real estate business structures, and consumer preferences.

These results suggest that more comprehensive planning and policy approaches may be required for designing neighborhoods for older adults. The findings in Chapter 3 suggest that suburban neighborhoods' community effect on behavior tends to be stronger than their neighborhood (physical design) effect, and thus that some social/policy program efforts can be focused on "social" as opposed to "physical" infrastructures. For example, for suburban neighborhoods where residents are aging in place, application of community features in age-restricted neighborhoods or NORCs would be a promising approach to encourage active and healthy aging. Physical improvement strategies for suburban neighborhoods – for example, providing older residents with open spaces or recreational facilities – need to be carefully evaluated, since their effects can be marginal in relation to desired outcomes. The findings – the significant effect of proximity to destinations and the homogeneous single-family detached suburban housing stock – suggest the importance of providing diverse housing options for suburban older adults, in terms of locations (preferably closer to destinations and services) and unit types (e.g., size and price, as well as multi-family versus single-family). This is because older adults in suburbs who intend to or have to relocate may need available housing options with sufficient nearby destinations and services to maintain their active lifestyle later in life, yet not too far from family members, friends, or towns they are familiar with.

5.7. Limitations and Future Research

Lastly, this dissertation ends with a discussion of limitations. This section suggests several promising ways to overcome these limitations and extend the research. Further investigation could make significant contributions in the following areas:

Examining supply side of age-restricted neighborhoods

This analysis placed an emphasis on the demand side of age-restricted neighborhoods. But the supply side – i.e., developers and local governments' behavior – can shed additional light on the age-restricted neighborhood phenomenon. Developers' various decisions, including the choice to build age-restricted developments and the designs and locations of the neighborhoods, reflect the demographic shifts and baby boomers' attitudes and preferences, manifested as market demand. Many local governments also have supported age-restricted developments, streamlining processes and providing incentives. Understanding these two players' decision behavior would allow us to outline possible implementation strategies for future elderly neighborhood planning.

Exploring other neighborhood types for older adults

While this dissertation focused on age-restricted neighborhoods, other types of elderly housing options deserve further investigation. In particular, there are naturally occurring retirement communities (NORCs) where the majority of their residents have become older adults who are remaining in their existing homes, and where service organizations offer various services for elderly residents. A NORC connects elders to supportive services and to each other, often using computer technology as a key tool (Bookman, 2008). Just as the second essay in Chapter 3 identified the significant effect of social "community," examining NORCs' community features can also offer insight into a promising approach to provide desirable social settings that can promote active aging. For instance, comparing community effects on behavior between NORC and age-restricted neighborhoods could offer further insight. Lastly, investigating the effectiveness of elderly service provision through computer and mobile technology may provide insight into a widely-applicable elderly service provision tool using information and communication technology.

Incorporating additional indicators

Fundamentally, the behavioral outcomes in the analysis served as proxies for the concept of active and healthy aging. There are many other factors – e.g., levels of physical activity, automobile dependency, social engagement, residential satisfaction, safety, and/or physical and mental health conditions – which are akin to the concept. Inclusion of those multiple indicators would improve the validity of the analysis by more rigorously operationalizing the concept of active and healthy aging. On the other hand, examining additional trip types, such as shopping, driving, riding, public transportation use, errands, etc., would offer more comprehensive understanding of baby boomers' lifestyles.

Including qualitative measures of urban form

This analysis "objectively" measured urban form to capture urban qualities through quantifications.

However, many urban design qualities, such as imageability, enclosure, human scale, transparency, and complexity, are highly subjective values. It is undeniable that may account for the heterogeneity of the way people to respond to the "actual" built environment and might even account for insignificant (or significant) effects of the "objectively" measured the built environment. There have been attempts to develop qualitative measures (e.g., Ewing & Handy, 2009), using ratings from an expert panel, and operationalize them with multivariate regression analyses. Although these attempts are crucial for taking into account environmental qualities, their validity and reliability are still problematic due to the subjective nature of these measures. In particular, the evaluation of an "expert panel" can be problematic regarding validity, since experts' opinion can be systematically different from responses of "users." Therefore, including qualitative measures into analyses, taking into account older users' ratings, would enhance our understanding of how older people react to environmental qualities.

Measuring micro-scale urban form elements

Measuring urban form, this analysis heavily emphasized neighborhood-level characteristics. However, various micro-scale neighborhood characteristics influence local walking and social behavior. For example, micro-scale measures, such as sidewalk availability and condition, existence of trees, and crosswalk design, are likely to influence baby boomers' behavior. However, inclusion of micro-scale measures requires considerable additional data collection efforts, using street audits or subjective built environment measures (i.e., typically a survey that asks respondents to rate environmental qualities).

Analyzing longitudinal behavioral data

The modeling approach of this dissertation made advances in estimating causal effects by controlling for self-selection. However, cross-sectional data are accompanied by their fundamental limitation in capturing behavioral changes induced by changes in environments. Collecting longitudinal data of baby boomers' behavior would offer valuable opportunities to strengthen causal inference.

Understanding marginal and relative effects

A weakness of complex SEM modeling is the difficulty of computing relative or marginal effects. Also, it is difficult to construct predictive models from SEM to estimate behavioral outcomes. Hence the SEM models in Chapter 3 and 4 revealed only significance of variables. A Monte Carlo simulation approach would provide ways to such construct predictive models to estimate older adults' activity levels.

Addressing spatial dependency and heterogeneity

The analysis identified strong evidence of spatial dependency (i.e., unobserved correlation among observations due to spatial proximity) and heterogeneity (i.e., uneven effects across geographical areas). The clustering structure – i.e., a group of suburban baby boomers in a neighborhood influencing neighbors' behavior in Chapter 3 – implies potential dependency among neighbors. Also, he clusters of traffic accidents observed in Chapter 4 suggest the existence of spatial dependency. Spatial dependency, when ignored, can lead to inconsistent estimations of effects (Case, 1992). Second, spatial heterogeneity refers to the variations in relationships between the dependent variables (e.g., behavioral outcomes) and independent variables (e.g., urban form elements) across spatial units or locations. The different neighborhood effects between urban and suburban areas are a sign of spatial heterogeneity. This implies that the magnitude, sign, and significance of neighborhood effects may differ across the region. Therefore, ignoring the mismatch between local and global relationships may result in inconsistent estimation of spatial effects (Bhat & Zhao, 2002). Further analyses accounting for spatial dependency and heterogeneity would improve the validity of behavioral modeling, as well as allow more sophisticated understanding of spatial patterns of behavior.

Conducting parallel studies in other metropolitan areas and in other countries

Parallel studies in other metropolitan areas in the US and international contexts can enhance local understanding of older adults' behavior, as well as improve the generalizability of this study. Empirically focusing on the Boston metropolitan area, the dissertation's external validity is limited to North American cities similar to Boston. The built environments and behavioral patterns of Sun Belt cities or other countries may differ from those of Boston. For example, the urban form of rapidly developing Asian cities is often highly automobile-dependent, discouraging sustainable mobility and accessibility.

Expanding the cohort of interest into other vulnerable groups

Similar to older adults, other vulnerable groups, such as children and people dealing with disabilities, are highly sensitive to environmental qualities. However, current built environments in many countries are often not supportive and safe for them. In particular, neighborhood- and street-level environments are likely to influence the safety and obesity of children. Hence, the investigation of children's behavior would enlighten planners about safer (e.g., fewer traffic accidents and lower fatality rates) and healthier (e.g., more physical activities) environments for this young group.

This dissertation contributes to an improved understanding of how neighborhood design influences baby boomers' walking, social engagement, and safety. It proposed conceptual frameworks to analyze complex relationships among the built environment, behavior, psychological factors, and safety. This framework incorporates easily ignored yet important factors, such as older adults' attitudes and preferences that may affect their housing choice and associated lifestyle. Hence, the dissertation argues that understanding without taking into account the complex relationships may lead to misunderstanding and bias. The empirical analyses in this framework support this argument, by identifying the significant influence of psychological factors and the countervailing direct and indirect effects among the factors.

This conceptual framework and findings should be transmitted to a broader audience of urban designers, planners, developers, and policy makers who are involved in the process of neighborhood design and provision, in order to help them to gain more sophisticated understanding of elderly neighborhood design that really works. However, this research is accompanied by the limitations related to the validity and generalizability of analysis, as well as the measurement of concepts and the built environment. Further research, as discussed above, would provide more valid and globally applicable lessons for urban planning and policy that can promote sustainable lifestyles for older adults in the US and other countries that are experiencing the process of aging.

Appendix

Table A-1. Principal Components of Suburban Baby Boomers' Residential Preference (n=1,745)

Residential Preference	***Pro Walkability***	***Pro Segregation***	***Pro Age-Restricted***
I_1: I prefer to have shops and services within walking distance	0.74	0.20	-0.25
I_2: I do not value space around my house more than having shops nearby	0.75	-0.10	0.36
I_3: I like a neighborhood containing housing, shops and services	0.71	0.24	-0.12
I_4: I do not prefer a lot of space between my home and the street	0.56	-0.09	0.53
I_5: I prefer a house close to the sidewalk so that I can see passersby	0.59	0.07	-0.28
I_6: I prefer neighbors at the same stage of life as me	-0.03	0.83	0.18
I_7: I prefer living around people who are similar to me	0.01	0.78	-0.09
I_8: I am concerned about strangers walking through my neighborhood	-0.21	0.47	-0.34
I_9: I like to live in a neighborhood without children in it	-0.29	0.40	0.67
Eigenvalue	2.40	1.80	1.18
Proportion Explained	0.27	0.20	0.13
Cumulative Proportion	0.27	0.47	0.60

Note: Principal components with an eigenvalue greater than 1 are included. The composite variables which significantly affect recreational NMT and social trips are selected (Pro Walkability and Pro Segregation) for a confirmatory factor analysis.

Table A-2. Confirmatory Factor Analysis of Suburban Baby Boomers' Residential Preference (n=1,842)

	Coefficient	*(S.E.)*
Pro Walkability		
I_1: I prefer to have shops and services within walking distance	1.000	(0.000)
I_2: I do not value space around my house more than having shops nearby	0.838**	(0.047)
I_3: I like a neighborhood containing housing, shops and services	0.960**	(0.042)
I_4: I do not prefer a lot of space between my home and the street	0.458**	(0.040)
I_5: I prefer a house close to the sidewalk so that I can see passersby	0.593**	(0.039)
Pro Segregation		
I_6: I prefer neighbors at the same stage of life as me	1.000	(0.000)
I_7: I prefer living around people who are similar to me	0.494**	(0.054)
I_8: I am concerned about strangers walking through my neighborhood	0.249**	(0.042)
I_9: I like to live in a neighborhood without children in it	0.343**	(0.040)
CFI	0.763	
TLI	0.672	
RMSEA	0.122	
RMSEA	0.079	

Note: † p<0.10, * p<0.05, ** p<0.01

Table A-3. Recreational NMT Trips Zero-inflated Negative Binomial (ZINB) Model Results

	Model 1: ZINB Without Latent Variables		Model 2: SEM With Latent Variables		Model 3: SEM With Age-Restricted Choice Model	
	Coeff.	(S.E.)	Coeff.	(S.E.)	Coeff.	(S.E.)
Logit Model (zero-inflation) Estimating *Likelihood of being in non-active group*						
Age-restricted	-0.519*	(0.244)	-0.602*	(0.249)	-0.610*	(0.250)
Pro Walkability			-0.212*	(0.098)	-0.213*	(0.097)
Pro Segregation			0.210*	(0.095)	0.208*	(0.094)
Grid	-0.172	(0.182)	-0.188	(0.181)	-0.188	(0.181)
Loop	0.059	(0.179)	0.055	(0.181)	0.056	(0.181)
Intersection Density	-0.296	(0.422)	-0.211	(0.413)	-0.210	(0.413)
Facilities	-0.027	(0.165)	-0.010	(0.166)	-0.009	(0.166)
Destination 400	0.017	(0.160)	0.060	(0.161)	0.060	(0.161)
MBTA Bus Stop	-0.166	(0.283)	-0.092	(0.284)	-0.093	(0.284)
Commuter Rail	-0.053	(0.180)	-0.041	(0.184)	-0.041	(0.184)
Street Length	0.004	(0.009)	0.002	(0.009)	0.002	(0.009)
Employ	0.578**	(0.166)	0.606**	(0.167)	0.606**	(0.167)
Healthy	-0.743**	(0.196)	-0.788**	(0.196)	-0.788**	(0.196)
Male	0.027	(0.134)	-0.048	(0.137)	-0.048	(0.137)
Age	0.011	(0.020)	0.012	(0.020)	0.012	(0.020)
High Income	-0.129	(0.205)	-0.102	(0.207)	-0.102	(0.207)
Mid Income	0.053	(0.190)	0.067	(0.190)	0.066	(0.190)
Three Vehicles	-0.096	(0.164)	-0.165	(0.167)	-0.165	(0.167)
Bike	-0.449**	(0.146)	-0.430**	(0.148)	-0.430**	(0.148)
Constant	-0.466	(1.295)	-0.509	(1.311)	-0.511	(1.311)
Negative Binomial Model Estimating *Number of NMT trips among active group*						
Age-restricted	0.053	(0.087)	0.078	(0.087)	0.080	(0.088)
Pro Walkability			-0.032	(0.038)	-0.031	(0.038)
Pro Segregation			-0.037	(0.036)	-0.037	(0.036)
Grid	0.001	(0.069)	0.007	(0.069)	0.007	(0.069)
Loop	-0.034	(0.068)	-0.029	(0.068)	-0.029	(0.068)
Intersection Density	-0.050	(0.115)	-0.052	(0.113)	-0.052	(0.113)
Facilities	0.000	(0.066)	0.010	(0.066)	0.010	(0.066)
Destination 400	0.128	(0.060)	0.139*	(0.060)	0.139*	(0.060)
MBTA Bus Stop	0.101	(0.108)	0.099	(0.105)	0.099	(0.105)
Commuter Rail	-0.163*	(0.068)	-0.177*	(0.068)	-0.177*	(0.068)
Street Length	0.001	(0.003)	0.000	(0.003)	0.000	(0.003)
Employ	-0.227**	(0.055)	-0.234**	(0.056)	-0.234**	(0.056)
Healthy	0.065	(0.078)	0.063	(0.078)	0.063	(0.078)
Male	-0.020	(0.049)	-0.022	(0.049)	-0.022	(0.049)
Age	-0.004	(0.007)	-0.003	(0.007)	-0.003	(0.007)
High Income	-0.015	(0.074)	-0.014	(0.074)	-0.014	(0.074)
Mid Income	-0.035	(0.071)	-0.041	(0.071)	-0.041	(0.071)
Three Vehicles	-0.038	(0.063)	-0.046	(0.062)	-0.046	(0.062)
Bike	0.034	(0.055)	0.030	(0.055)	0.030	(0.055)
Constant	1.569**	(0.422)	1.552**	(0.422)	1.552**	(0.422)
Alpha	0.089**	(0.024)	0.088**	(0.024)	0.088**	(0.024)
N	1456		1456		1456	
# of Parameters	37		84		102	
# of Observed Variables	18		27		27	
Identification			Overidentified 84 < 0.5*27*(27+1)		Overidentified 102 < 0.5*27*(27+1)	

Note: † p<0.10, * p<0.05, ** p<0.01 (Continued)

Table A-3. (continued) Recreational NMT Model Results

	Model 1: ZINB Without Latent Variables		Model 2: SEM With Latent Variables		Model 3: SEM With Age-Restricted Choice Model	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Measurement Model Estimating:						
Pro Walkability						
I_1: I prefer to have shops and services within walking distance			1.000	(0.000)	1.000	(0.000)
I_2: I do not value space around my house more than shops nearby			0.889**	(0.094)	0.888**	(0.094)
I_3: I like a neighborhood containing housing, shops and services			0.927**	(0.046)	0.926**	(0.046)
I_4: I do not prefer a lot of space between my home and the street			0.515**	(0.080)	0.515**	(0.080)
I_5: I prefer a house close to the sidewalk so that I can see passersby			0.621**	(0.050)	0.620**	(0.050)
Pro Segregation						
I_6: I prefer neighbors at the same stage of life as me			1.000	(0.000)	1.000	(0.000)
I_7: I prefer living around people who are similar to me			0.589**	(0.082)	0.586**	(0.081)
I_8: I am concerned about strangers walking through my NBHD.			0.462**	(0.087)	0.457**	(0.085)
I_9: I like to live in a neighborhood without children in it			0.354**	(0.061)	0.353**	(0.060)
Structural (MIMIC) Model Estimating:						
Pro Walkability						
Employ			-0.010	(0.067)	-0.011	(0.068)
Healthy			-0.024	(0.083)	-0.024	(0.084)
Male			-0.226**	(0.053)	-0.227**	(0.053)
Age			0.004	(0.008)	0.003	(0.008)
High Income			0.044	(0.091)	0.044	(0.091)
Mid Income			-0.094	(0.080)	-0.094	(0.080)
Three Vehicles			-0.301**	(0.076)	-0.301**	(0.076)
Bike			-0.046	(0.068)	-0.046	(0.068)
Pro Segregation						
Employ			-0.167*	(0.065)	-0.168*	(0.065)
Healthy			0.124	(0.081)	0.125	(0.080)
Male			0.126*	(0.049)	0.126*	(0.049)
Age			-0.001	(0.008)	-0.001	(0.008)
High Income			-0.030	(0.091)	-0.031	(0.091)
Mid Income			-0.077	(0.079)	-0.077	(0.079)
Three Vehicles			0.029	(0.070)	0.029	(0.070)
Bike			-0.128*	(0.065)	-0.128*	(0.065)
Logit Model Estimating *Likelihood of choosing age-restricted neighborhood*						
Pro Walkability					0.140	(0.179)
Pro Segregation					0.810**	(0.147)
Loop					5.979**	(0.708)
Intersection Density					2.206**	(0.384)
Facilities					3.393**	(0.341)
Destination 400					-0.116	(0.299)
MBTA Bus Stop					-2.647**	(0.940)
Commuter Rail					0.199	(0.433)
Street Length					0.106**	(0.014)
Employ					-0.259	(0.270)
Healthy					0.530	(0.340)
Male					-0.442*	(0.192)
Age					0.205**	(0.037)
High Income					1.302**	(0.397)
Mid Income					0.470	(0.329)
Three Vehicles					-0.268	(0.437)
Bike					-0.323	(0.267)

Table A-4. Social Trips Zero-inflated Negative Binomial (ZINB) Model Results

	Model 1: ZINB Without Latent Variables		Model 2: SEM With Latent Variables		Model 3: SEM With Age-Restricted Choice Model	
	Coeff.	(S.E.)	Coeff.	(S.E.)	Coeff.	(S.E.)
Logit Model (zero-inflation) Estimating *Likelihood of being in non-active group*						
Age-restricted	0.030	(0.512)	-0.102	(0.611)	-0.111	(0.621)
Pro Walkability			-0.240	(0.297)	-0.238	(0.297)
Pro Segregation			0.192	(0.283)	0.194	(0.281)
Grid	0.543	(0.587)	0.400	(0.528)	0.399	(0.526)
Loop	0.147	(0.547)	0.087	(0.453)	0.089	(0.453)
Intersection Density	-1.379	(1.337)	-1.175	(1.062)	-1.175	(1.062)
Facilities	-0.486	(0.518)	-0.360	(0.430)	-0.360	(0.430)
Destination 400	-0.395	(0.447)	-0.217	(0.452)	-0.217	(0.451)
MBTA Bus Stop	-1.404	(2.151)	-1.066	(2.118)	-1.064	(2.109)
Commuter Rail	1.200†	(0.619)	1.108†	(0.600)	1.110†	(0.603)
Street Length	-0.008	(0.017)	-0.013	(0.016)	-0.013	(0.016)
Employ	0.525	(0.395)	0.560	(0.360)	0.560	(0.360)
Healthy	0.370	(0.573)	0.374	(0.595)	0.374	(0.595)
Male	0.819*	(0.370)	0.748†	(0.421)	0.749†	(0.422)
Age	0.051	(0.048)	0.040	(0.045)	0.040	(0.045)
High Income	0.400	(0.756)	0.382	(0.682)	0.384	(0.683)
Mid Income	0.452	(0.600)	0.458	(0.602)	0.460	(0.605)
Three Vehicles	-0.360	(0.649)	-0.402	(0.675)	-0.404	(0.677)
Bike	0.074	(0.321)	0.048	(0.311)	0.049	(0.312)
Constant	-4.486	(3.544)	-3.778	(3.513)	-3.776	(3.519)
Negative Binomial Model Estimating *Number of social trips among social group*						
Age-restricted	0.576**	(0.212)	0.479*	(0.239)	0.471†	(0.242)
Pro Walkability			-0.018	(0.128)	-0.017	(0.128)
Pro Segregation			0.156	(0.111)	0.156	(0.110)
Grid	0.115	(0.196)	0.046	(0.202)	0.046	(0.201)
Loop	-0.157	(0.200)	-0.182	(0.184)	-0.180	(0.184)
Intersection Density	-0.264	(0.303)	-0.244	(0.273)	-0.242	(0.273)
Facilities	-0.188	(0.186)	-0.166	(0.173)	-0.165	(0.173)
Destination 400	0.142	(0.173)	0.196	(0.195)	0.196	(0.195)
MBTA Bus Stop	-0.659	(0.481)	-0.603	(0.595)	-0.603	(0.593)
Commuter Rail	0.342*	(0.167)	0.352†	(0.182)	0.353†	(0.182)
Street Length	-0.008	(0.007)	-0.009	(0.006)	-0.009	(0.006)
Employ	-0.368*	(0.168)	-0.327*	(0.151)	-0.327*	(0.151)
Healthy	-0.006	(0.187)	-0.006	(0.189)	-0.006	(0.189)
Male	0.144	(0.154)	0.144	(0.153)	0.145	(0.152)
Age	0.048*	(0.020)	0.043*	(0.020)	0.043*	(0.020)
High Income	-0.262	(0.268)	-0.259	(0.253)	-0.258	(0.254)
Mid Income	-0.155	(0.198)	-0.126	(0.207)	-0.125	(0.207)
Three Vehicles	-0.185	(0.244)	-0.194	(0.261)	-0.195	(0.261)
Bike	0.262*	(0.133)	0.261*	(0.131)	0.262*	(0.131)
Constant	-2.518†	(1.285)	-2.243†	(1.319)	-2.241†	(1.320)
Alpha	0.360†	(0.215)	0.301	(0.200)	0.301	(0.201)
N	1410		1410		1410	
# of Parameters	37		84		102	
# of Observed Variables	18		27		27	
Identification			Overidentified 84 < 0.5*27*(27+1)		Overidentified 102 < 0.5*27*(27+1)	

Note: † p<0.10, * p<0.05, ** p<0.01 (Continued)

Table A-4. (continued) Social Trips Model Results

	Model 1: ZINB Without Latent Variables		Model 2: SEM With Latent Variables		Model 3: SEM With Age-Restricted Choice Model	
	Coeff.	(S.E.)	Coeff.	(S.E.)	Coeff.	(S.E.)
Measurement Model Estimating:						
Pro Walkability						
I_1: I prefer to have shops and services within walking distance			1.000	(0.000)	1.000	(0.000)
I_2: I do not value space around my house more than shops nearby			0.893**	(0.093)	0.893**	(0.093)
I_3: I like a neighborhood containing housing, shops and services			0.929**	(0.045)	0.929**	(0.045)
I_4: I do not prefer a lot of space between my home and the street			0.520**	(0.080)	0.520**	(0.080)
I_5: I prefer a house close to the sidewalk so that I can see passersby			0.625**	(0.051)	0.625**	(0.051)
Pro Segregation						
I_6: I prefer neighbors at the same stage of life as me			1.000	(0.000)	1.000	(0.000)
I_7: I prefer living around people who are similar to me			0.593**	(0.085)	0.588**	(0.084)
I_8: I am concerned about strangers walking through my NBHD.			0.465**	(0.090)	0.459**	(0.088)
I_9: I like to live in a neighborhood without children in it			0.354**	(0.060)	0.352**	(0.060)
Structural (MIMIC) Model Estimating:						
Pro Walkability						
Employ			-0.010	(0.067)	-0.010	(0.067)
Healthy			-0.024	(0.083)	-0.024	(0.083)
Male			-0.226**	(0.053)	-0.225**	(0.053)
Age			0.004	(0.008)	0.003	(0.008)
High Income			0.044	(0.091)	0.044	(0.091)
Mid Income			-0.093	(0.079)	-0.093	(0.079)
Three Vehicles			-0.300**	(0.076)	-0.300**	(0.076)
Bike			-0.046	(0.067)	-0.046	(0.067)
Pro Segregation						
Employ			-0.167*	(0.065)	-0.168*	(0.065)
Healthy			0.124	(0.081)	0.124	(0.081)
Male			0.126*	(0.049)	0.126*	(0.049)
Age			-0.001	(0.008)	-0.001	(0.008)
High Income			-0.031	(0.091)	-0.031	(0.092)
Mid Income			-0.078	(0.079)	-0.078	(0.079)
Three Vehicles			0.029	(0.070)	0.029	(0.070)
Bike			-0.128*	(0.064)	-0.128*	(0.065)
Logit Model Estimating *Likelihood of choosing age-restricted neighborhood*						
Pro Walkability					0.138	(0.180)
Pro Segregation					0.815**	(0.148)
Loop					5.982**	(0.708)
Intersection Density					2.205**	(0.384)
Facilities					3.397**	(0.341)
Destination 400					-0.112	(0.300)
MBTA Bus Stop					-2.641**	(0.940)
Commuter Rail					0.196	(0.432)
Street Length					0.106**	(0.014)
Employ					-0.261	(0.270)
Healthy					0.529	(0.340)
Male					-0.445*	(0.192)
Age					0.205**	(0.037)
High Income					1.303**	(0.397)
Mid Income					0.467	(0.329)
Three Vehicles					-0.266	(0.436)
Bike					-0.321	(0.267)

Table A-5. Sensitivity Analysis for the NMT model (n=1456)

	P=1%		*P*=3.2%		*P*=5%	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Logit Model (zero-inflation) Estimating *Likelihood of being in non-active group*						
Age-restricted	-0.619*	(0.257)	-0.610*	(0.250)	-0.604*	(0.247)
Pro Walkability	-0.207*	(0.099)	-0.213*	(0.097)	-0.216*	(0.097)
Pro Segregation	0.212*	(0.099)	0.208*	(0.094)	0.205*	(0.091)
Grid	-0.189	(0.182)	-0.188	(0.181)	-0.187	(0.181)
Loop	0.062	(0.183)	0.056	(0.181)	0.052	(0.180)
Intersection Density	-0.207	(0.424)	-0.210	(0.413)	-0.213	(0.406)
Facilities	-0.002	(0.168)	-0.009	(0.166)	-0.014	(0.165)
Destination 400	0.052	(0.166)	0.060	(0.161)	0.066	(0.158)
MBTA Bus Stop	-0.091	(0.289)	-0.093	(0.284)	-0.094	(0.281)
Commuter Rail	-0.040	(0.188)	-0.041	(0.184)	-0.042	(0.181)
Street Length	0.002	(0.010)	0.002	(0.009)	0.002	(0.009)
Employ	0.614**	(0.171)	0.606**	(0.167)	0.599**	(0.164)
Healthy	-0.802**	(0.200)	-0.788**	(0.196)	-0.778**	(0.193)
Male	-0.047	(0.140)	-0.048	(0.137)	-0.049	(0.135)
Age	0.012	(0.021)	0.012	(0.020)	0.012	(0.020)
High Income	-0.117	(0.211)	-0.102	(0.207)	-0.090	(0.204)
Mid Income	0.075	(0.194)	0.066	(0.190)	0.060	(0.187)
Three Vehicles	-0.163	(0.169)	-0.165	(0.167)	-0.166	(0.165)
Bike	-0.432**	(0.151)	-0.430**	(0.148)	-0.429**	(0.146)
Constant	-0.492	(1.337)	-0.511	(1.311)	-0.525	(1.293)
Negative Binomial Model Estimating *Number of NMT trips among active group*						
Age-restricted	0.090	(0.091)	0.080	(0.088)	0.073	(0.086)
Pro Walkability	-0.029	(0.039)	-0.031	(0.038)	-0.033	(0.037)
Pro Segregation	-0.044	(0.038)	-0.037	(0.036)	-0.032	(0.035)
Grid	0.006	(0.069)	0.007	(0.069)	0.008	(0.068)
Loop	-0.033	(0.069)	-0.029	(0.068)	-0.027	(0.067)
Intersection Density	-0.062	(0.119)	-0.052	(0.113)	-0.045	(0.110)
Facilities	0.009	(0.067)	0.010	(0.066)	0.011	(0.066)
Destination 400	0.147*	(0.062)	0.139*	(0.060)	0.134*	(0.058)
MBTA Bus Stop	0.099	(0.106)	0.099	(0.105)	0.099	(0.105)
Commuter Rail	-0.182*	(0.070)	-0.177*	(0.068)	-0.174*	(0.067)
Street Length	0.000	(0.003)	0.000	(0.003)	0.000	(0.003)
Employ	-0.235**	(0.058)	-0.234**	(0.056)	-0.233**	(0.054)
Healthy	0.066	(0.081)	0.063	(0.078)	0.061	(0.076)
Male	-0.021	(0.051)	-0.022	(0.049)	-0.022	(0.048)
Age	-0.004	(0.007)	-0.003	(0.007)	-0.003	(0.007)
High Income	-0.017	(0.077)	-0.014	(0.074)	-0.012	(0.073)
Mid Income	-0.044	(0.073)	-0.041	(0.071)	-0.039	(0.069)
Three Vehicles	-0.041	(0.063)	-0.046	(0.062)	-0.050	(0.061)
Bike	0.024	(0.057)	0.030	(0.055)	0.034	(0.054)
Constant	1.575**	(0.435)	1.552**	(0.422)	1.535**	(0.414)
Alpha	0.089**	(0.025)	0.088**	(0.024)	0.087**	(0.023)

Note: † p<0.10, * p<0.05, ** p<0.01

(Continued)

Table A-5. (continued) Sensitivity Analysis for the NMT model (n=1456)

	P=1%		*P*=3.2%		*P*=5%	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Measurement Model Estimating:						
Pro Walkability						
I_1	1.000	(0.000)	1.000	(0.000)	1.000	(0.000)
I_2	0.884**	(0.094)	0.888**	(0.094)	0.891**	(0.093)
I_3	0.924**	(0.047)	0.926**	(0.046)	0.927**	(0.045)
I_4	0.512**	(0.080)	0.515**	(0.080)	0.516**	(0.080)
I_5	0.623**	(0.050)	0.620**	(0.050)	0.618**	(0.049)
Pro Segregation						
I_6	1.000	(0.000)	1.000	(0.000)	1.000	(0.000)
I_7	0.599**	(0.085)	0.586**	(0.081)	0.578**	(0.078)
I_8	0.484**	(0.091)	0.457**	(0.085)	0.440**	(0.081)
I_9	0.353**	(0.063)	0.353**	(0.060)	0.354**	(0.059)
Structural (MIMIC) Model Estimating:						
Pro Walkability						
Employ	-0.001	(0.069)	-0.011	(0.068)	-0.017	(0.066)
Healthy	-0.024	(0.085)	-0.024	(0.084)	-0.023	(0.082)
Male	-0.228**	(0.055)	-0.227**	(0.053)	-0.225**	(0.053)
Age	0.003	(0.009)	0.003	(0.008)	0.003	(0.008)
High Income	0.035	(0.093)	0.044	(0.091)	0.050	(0.089)
Mid Income	-0.101	(0.082)	-0.094	(0.080)	-0.089	(0.078)
Three Vehicles	-0.300**	(0.077)	-0.301**	(0.076)	-0.301**	(0.075)
Bike	-0.044	(0.070)	-0.046	(0.068)	-0.047	(0.067)
Pro Segregation						
Employ	-0.160*	(0.067)	-0.168*	(0.065)	-0.173*	(0.065)
Healthy	0.118	(0.082)	0.125	(0.080)	0.129	(0.080)
Male	0.133**	(0.050)	0.126*	(0.049)	0.121*	(0.049)
Age	-0.003	(0.008)	-0.001	(0.008)	0.000	(0.008)
High Income	-0.045	(0.094)	-0.031	(0.091)	-0.020	(0.090)
Mid Income	-0.087	(0.080)	-0.077	(0.079)	-0.071	(0.078)
Three Vehicles	0.042	(0.071)	0.029	(0.070)	0.020	(0.069)
Bike	-0.131*	(0.066)	-0.128*	(0.065)	-0.126*	(0.064)
Logit Model Estimating *Likelihood of choosing age-restricted neighborhood*						
Pro Walkability	0.109	(0.187)	0.140	(0.179)	0.152	(0.175)
Pro Segregation	0.905**	(0.162)	0.810**	(0.147)	0.781**	(0.142)
Loop	7.333**	(0.977)	5.979**	(0.708)	5.574**	(0.635)
Intersection Density	2.812**	(0.439)	2.206**	(0.384)	2.016**	(0.376)
Facilities	3.650**	(0.362)	3.393**	(0.341)	3.306**	(0.336)
Destination 400	-0.223	(0.326)	-0.116	(0.299)	-0.081	(0.291)
MBTA Bus Stop	-3.245**	(0.975)	-2.647**	(0.940)	-2.403*	(0.943)
Commuter Rail	0.385	(0.502)	0.199	(0.433)	0.125	(0.412)
Street Length	0.139**	(0.017)	0.106**	(0.014)	0.095**	(0.013)
Employ	-0.359	(0.312)	-0.259	(0.270)	-0.232	(0.255)
Healthy	0.683	(0.379)	0.530	(0.340)	0.477	(0.328)
Male	-0.480*	(0.215)	-0.442*	(0.192)	-0.431*	(0.184)
Age	0.234**	(0.040)	0.205**	(0.037)	0.194**	(0.035)
High Income	1.482**	(0.434)	1.302**	(0.397)	1.250**	(0.385)
Mid Income	0.573	(0.357)	0.470	(0.329)	0.436	(0.320)
Three Vehicles	-0.480	(0.498)	-0.268	(0.437)	-0.214	(0.411)
Bike	-0.407	(0.291)	-0.323	(0.267)	-0.295	(0.258)

Note: † p<0.10, * p<0.05, ** p<0.01

Table A-6. Sensitivity Analysis for the Social Trip model (n=1410)

	P=1%		*P*=3.2%		*P*=5%	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Logit Model (zero-inflation) Estimating ***Likelihood of being in non-active group***						
Age-restricted	-0.127	(0.687)	-0.111	(0.621)	-0.101	(0.584)
Pro Walkability	-0.243	(0.340)	-0.238	(0.297)	-0.234	(0.272)
Pro Segregation	0.207	(0.338)	0.194	(0.281)	0.187	(0.251)
Grid	0.386	(0.553)	0.399	(0.526)	0.408	(0.508)
Loop	0.093	(0.470)	0.089	(0.453)	0.086	(0.442)
Intersection Density	-1.134	(1.160)	-1.175	(1.062)	-1.206	(1.010)
Facilities	-0.360	(0.440)	-0.360	(0.430)	-0.358	(0.422)
Destination 400	-0.186	(0.496)	-0.217	(0.451)	-0.234	(0.427)
MBTA Bus Stop	-1.095	(2.125)	-1.064	(2.109)	-1.042	(2.086)
Commuter Rail	1.114†	(0.680)	1.110†	(0.603)	1.089†	(0.563)
Street Length	-0.013	(0.018)	-0.013	(0.016)	-0.013	(0.015)
Employ	0.561	(0.382)	0.560	(0.360)	0.563	(0.346)
Healthy	0.421	(0.649)	0.374	(0.595)	0.346	(0.558)
Male	0.772	(0.484)	0.749†	(0.422)	0.736†	(0.386)
Age	0.041	(0.048)	0.040	(0.045)	0.038	(0.043)
High Income	0.430	(0.768)	0.384	(0.683)	0.355	(0.640)
Mid Income	0.527	(0.726)	0.460	(0.605)	0.420	(0.540)
Three Vehicles	-0.452	(0.783)	-0.404	(0.677)	-0.373	(0.616)
Bike	0.070	(0.329)	0.049	(0.312)	0.035	(0.302)
Constant	-4.030	(3.944)	-3.776	(3.519)	-3.623	(3.284)
Negative Binomial Model Estimating ***Number of social trips among social group***						
Age-restricted	0.498†	(0.263)	0.471†	(0.242)	0.455*	(0.231)
Pro Walkability	-0.020	(0.148)	-0.017	(0.128)	-0.014	(0.117)
Pro Segregation	0.157	(0.127)	0.156	(0.110)	0.156	(0.101)
Grid	0.042	(0.213)	0.046	(0.201)	0.049	(0.194)
Loop	-0.187	(0.188)	-0.180	(0.184)	-0.176	(0.181)
Intersection Density	-0.278	(0.302)	-0.242	(0.273)	-0.223	(0.258)
Facilities	-0.161	(0.176)	-0.165	(0.173)	-0.167	(0.171)
Destination 400	0.234	(0.220)	0.196	(0.195)	0.172	(0.180)
MBTA Bus Stop	-0.627	(0.591)	-0.603	(0.593)	-0.588	(0.594)
Commuter Rail	0.367†	(0.194)	0.353†	(0.182)	0.345*	(0.175)
Street Length	-0.011	(0.007)	-0.009	(0.006)	-0.008	(0.006)
Employ	-0.330*	(0.159)	-0.327*	(0.151)	-0.323*	(0.146)
Healthy	-0.016	(0.195)	-0.006	(0.189)	-0.021	(0.183)
Male	0.153	(0.165)	0.145	(0.152)	0.139	(0.143)
Age	0.045*	(0.020)	0.043*	(0.020)	0.042*	(0.019)
High Income	-0.243	(0.276)	-0.258	(0.254)	-0.267	(0.241)
Mid Income	-0.107	(0.236)	-0.125	(0.207)	-0.136	(0.190)
Three Vehicles	-0.209	(0.286)	-0.195	(0.261)	-0.186	(0.246)
Bike	0.270*	(0.137)	0.262*	(0.131)	0.256*	(0.128)
Constant	-2.372†	(1.382)	-2.241†	(1.320)	-2.152†	(1.280)
Alpha	0.315	(0.237)	0.301	(0.201)	0.292	(0.180)

Note: † p<0.10, * p<0.05, ** p<0.01 (Continued)

Table A-6. (continued) Sensitivity Analysis for the Social Trip model (n=1410)

	P=1%		*P*=3.2%		*P*=5%	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Measurement Model Estimating:						
Pro Walkability						
I_1	1.000	(0.000)	1.000	(0.000)	1.000	(0.000)
I_2	0.889**	(0.093)	0.888**	(0.094)	0.896**	(0.092)
I_3	0.928**	(0.046)	0.926**	(0.046)	0.931**	(0.045)
I_4	0.517**	(0.080)	0.515**	(0.080)	0.522**	(0.080)
I_5	0.628**	(0.051)	0.620**	(0.050)	0.623**	(0.050)
Pro Segregation						
I_6	1.000	(0.000)	1.000	(0.000)	1.000	(0.000)
I_7	0.604**	(0.088)	0.586**	(0.081)	0.579**	(0.081)
I_8	0.488**	(0.094)	0.457**	(0.085)	0.442**	(0.083)
I_9	0.352**	(0.063)	0.353**	(0.060)	0.353**	(0.058)
Structural (MIMIC) Model Estimating:						
Pro Walkability						
Employ	-0.001	(0.069)	-0.011	(0.068)	-0.016	(0.066)
Healthy	-0.025	(0.085)	-0.024	(0.084)	-0.024	(0.082)
Male	-0.227**	(0.054)	-0.227**	(0.053)	-0.224**	(0.052)
Age	0.003	(0.009)	0.003	(0.008)	0.004	(0.008)
High Income	0.035	(0.093)	0.044	(0.091)	0.050	(0.089)
Mid Income	-0.100	(0.081)	-0.094	(0.080)	-0.089	(0.078)
Three Vehicles	-0.299**	(0.077)	-0.301**	(0.076)	-0.300**	(0.075)
Bike	-0.045	(0.069)	-0.046	(0.068)	-0.048	(0.066)
Pro Segregation						
Employ	-0.160*	(0.066)	-0.168*	(0.065)	-0.173**	(0.065)
Healthy	0.117	(0.082)	0.125	(0.080)	0.129	(0.080)
Male	0.133**	(0.050)	0.126*	(0.049)	0.121*	(0.049)
Age	-0.003	(0.008)	-0.001	(0.008)	0.000	(0.008)
High Income	-0.046	(0.094)	-0.031	(0.091)	-0.021	(0.090)
Mid Income	-0.088	(0.081)	-0.077	(0.079)	-0.071	(0.078)
Three Vehicles	0.042	(0.070)	0.029	(0.070)	0.020	(0.069)
Bike	-0.131*	(0.066)	-0.128*	(0.065)	-0.126*	(0.064)
Logit Model Estimating *Likelihood of choosing age-restricted neighborhood*						
Pro Walkability	0.106	(0.188)	0.140	(0.179)	0.150	(0.176)
Pro Segregation	0.913**	(0.163)	0.810**	(0.147)	0.784**	(0.143)
Loop	7.338**	(0.976)	5.979**	(0.708)	5.577**	(0.636)
Intersection Density	2.809**	(0.439)	2.206**	(0.384)	2.016**	(0.377)
Facilities	3.654**	(0.361)	3.393**	(0.341)	3.309**	(0.336)
Destination 400	-0.217	(0.326)	-0.116	(0.299)	-0.078	(0.291)
MBTA Bus Stop	-3.239**	(0.974)	-2.647**	(0.940)	-2.397*	(0.943)
Commuter Rail	0.381	(0.501)	0.199	(0.433)	0.122	(0.411)
Street Length	0.139**	(0.017)	0.106**	(0.014)	0.095**	(0.013)
Employ	-0.358	(0.311)	-0.259	(0.270)	-0.234	(0.255)
Healthy	0.682	(0.379)	0.530	(0.340)	0.477	(0.327)
Male	-0.485*	(0.216)	-0.442*	(0.192)	-0.434*	(0.185)
Age	0.235**	(0.040)	0.205**	(0.037)	0.195**	(0.035)
High Income	1.484**	(0.435)	1.302**	(0.397)	1.252**	(0.385)
Mid Income	0.570	(0.357)	0.470	(0.329)	0.433	(0.320)
Three Vehicles	-0.476	(0.497)	-0.268	(0.437)	-0.213	(0.410)
Bike	-0.403	(0.292)	-0.323	(0.267)	-0.293	(0.258)

Note: † p<0.10, * p<0.05, ** p<0.01

Table A-7. Principal Components of Urban Baby Boomers' Psychological Indicators (n=914)

Residential Preference	***Pro Segregation***	***Pro Age-Restricted***
I_1: If I wanted to walk, I am unlikely to do it because I am concerned about falling or injuring myself.	-0.64	0.56
I_2: If I wanted to walk, I am unlikely to do it because I am concerned about being in an accident with cars or trucks.	-0.69	0.51
I_3: For me to walk to get to shopping, banking, meeting a doctor, or errands would overall be unsafe.	0.66	-0.03
I_4: Most people who are important to me think that I should walk.	-0.51	0.69
I_5: Most people who are important to me would support me if I choose to walk rather than drive.	0.57	0.67
Eigenvalue	1.90	1.50
Proportion Explained	0.38	0.38
Cumulative Proportion	0.30	0.68

Note: Principal components with an eigenvalue greater than 1 are included.

Table A-8. Confirmatory Factor Analysis of Urban Baby Boomers' Psychological Indicators (n=914)

	Coefficient	***(S.E.)***
Pro Walkability		
I_1: Injury Concern	1.000	(0.000)
I_2: Accident Concern	1.006**	(0.121)
I_3: Recreational Risk	0.385**	(0.050)
Pro Segregation		
I_4: Should Walk	1.000	(0.000)
I_5: Support Walking	1.350*	(0.770)
CFI	0.941	
TLI	0.851	
RMSEA	0.116	
RMSEA	0.060	

Note: † p<0.10, * p<0.05, ** p<0.01

Table A-9. Utilitarian Walking Model Results (N = 914)

	Negative Binomial Model		Structural (MIMIC) Model & Measurement Model					
	Number of Utilitarian Walking		*Traffic Accident*		*Safety Concern*		*Supportive Social Norms*	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Endogenous Variables								
Traffic Accident	-0.004*	(0.002)	-	-	-	-	-	-
Safety Concern	-0.131**	(0.049)	-	-	-	-	-	-
Supportive Social Norms	0.109*	(0.043)	-	-	-	-	-	-
Exogenous Variables								
Net FAR	0.010	(0.021)	0.021	(0.987)	-	-	-	-
Land Use Diversity	0.737**	(0.241)	-5.480	(5.384)	-	-	-	-
Intersection Density	0.115*	(0.057)	-4.180**	(1.557)	-	-	-	-
Open Space Density	-0.005	(0.005)	-0.514**	(0.109)	-	-	-	-
Trail Length	-0.069	(0.155)	7.102	(5.660)	-	-	-	-
Hilliness	-0.042	(0.030)	-2.594**	(0.746)	-	-	-	-
Accessibility to Retail	0.737*	(0.289)	21.129*	(9.320)	-	-	-	-
Accessibility to Transit	0.174	(0.136)	0.831	(3.565)	-	-	-	-
Speed Limit	0.024**	(0.008)	0.666**	(0.196)	-	-	-	-
AM Traffic Volume	0.001	(0.002)	0.570**	(0.040)	-	-	-	-
High-Income	-0.153†	(0.085)	-	-	-0.426**	(0.113)	0.311†	(0.180)
Mid-Income	-0.082	(0.075)	-	-	-0.231*	(0.112)	0.198†	(0.119)
Disability	-0.445**	(0.151)	-	-	0.586**	(0.183)	-0.177	(0.212)
Employ	-0.004	(0.053)	-	-	-0.022	(0.066)	-0.052	(0.092)
Male	0.010	(0.049)	-	-	-0.076	(0.054)	-0.081	(0.100)
Own a Dog	0.145†	(0.082)	-	-	-0.055	(0.071)	-0.082	(0.090)
Own a Bike	0.084	(0.053)	-	-	-0.069	(0.067)	0.077	(0.074)
Own a Car	-0.182**	(0.060)	-	-	0.020	(0.090)	-0.005	(0.085)
Dispersion	0.379**	(0.033)	-	-	-	-	-	-

Note: † $p<0.10$, * $p<0.05$, ** $p<0.01$

(Continued)

Table A-9. (continued) Utilitarian Walking Model Results (N = 914)

	Negative Binomial Model		**Structural (MIMIC) Model & Measurement Model**					
	Number of Utilitarian Walking		*Traffic Accident*		*Safety Concern*		*Supportive Social Norms*	
	Coeff.	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**	**Coeff.**	**(S.E.)**
Psychological Indicators								
I_1: *Injury Concern*	-	-	-	-	1.000	(0.000)	-	-
I_2: *Accident Concern*	-	-	-	-	0.796**	(0.111)	-	-
I_3: *Recreational Risk*	-	-	-	-	0.420**	(0.099)	-	-
I_4: *Should Walk*	-	-	-	-	-	-	1.000	(0.000)
I_5: *Support Walking*	-	-	-	-	-	-	1.088*	(0.508)

Note: † p<0.10, * p<0.05, ** p<0.01; The model is over identified with 66 free parameters and 25 observed variables (66 < 0.5*25*(25+1)).

Table A-10. Recreational Walking Model Results (N = 914)

	Zero-Inflated Negative Binomial Model		Structural (MIMIC) Model & Measurement Model		
	Likelihood of being in Non-active group	*Number of Recreational Walking*	*Traffic Accident*	*Safety Concern*	*Supportive Social Norms*
	Coeff. (S.E.)	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**
Endogenous Variables					
Traffic Accident	0.018*	0.001	-	-	-
	(0.007)	(0.002)			
Safety Concern	0.323†	0.040	-	-	-
	(0.171)	(0.059)			
Supportive Social	-0.419**	0.051	-	-	-
Norms	(0.134)	(0.037)			
Exogenous Variables					
Net FAR	0.062	0.068**	0.021	-	-
	(0.083)	(0.021)	(0.987)		
Land Use Diversity	0.364	1.087**	-5.480	-	-
	(1.077)	(0.289)	(5.384)		
Intersection	-0.492†	-0.007	-4.180**	-	-
Density	(0.279)	(0.071)	(1.557)		
Open Space	-0.009	0.008†	-0.514**	-	-
Density	(0.017)	(0.005)	(0.109)		
Trail Length	-0.260	-0.161	7.102	-	-
	(0.720)	(0.209)	(5.660)		
Hilliness	0.008	-0.048	-2.594**	-	-
	(0.114)	(0.033)	(0.746)		
Accessibility to	-1.516	-0.324	21.129*	-	-
Retail	(2.165)	(0.392)	(9.320)		
Accessibility to	-1.710*	0.090	0.831	-	-
Transit	(0.794)	(0.152)	(3.565)		
Speed Limit	-0.030	0.002	0.666**	-	-
	(0.033)	(0.010)	(0.196)		
AM Traffic Volume	-0.011	-0.005*	0.570**	-	-
	(0.009)	(0.002)	(0.040)		
High-Income	0.030	0.078	-	-0.444**	0.403**
	(0.376)	(0.102)		(0.114)	(0.140)
Mid-Income	-0.094	0.037	-	-0.244*	0.219
	(0.326)	(0.096)		(0.114)	(0.139)
Disability	0.540	-0.286†	-	0.585**	-0.272
	(0.428)	(0.157)		(0.184)	(0.220)
Employ	0.294	-0.221**	-	-0.027	-0.109
	(0.229)	(0.067)		(0.067)	(0.093)
Male	0.187	0.017	-	-0.087	-0.165*
	(0.218)	(0.062)		(0.056)	(0.081)
Own a Dog	-0.354	0.580**	-	-0.054	-0.082
	(0.342)	(0.083)		(0.073)	(0.119)
Own a Bike	-0.062	0.026	-	-0.063	-0.008
	(0.236)	(0.068)		(0.068)	(0.121)
Own a Car	-0.261	-0.151†	-	0.019	0.038
	(0.264)	(0.088)		(0.092)	(0.116)
Dispersion	-	0.314**	-	-	-
		(0.037)			

Note: † p<0.10, * p<0.05, ** p<0.01

(Continued)

Table A-10. (continued) Recreational Walking Model Results (N = 914)

	Zero-Inflated Negative Binomial Model		**Structural (MIMIC) Model & Measurement Model**		
	Likelihood of being in Non-active group	*Number of Recreational Walking*	*Traffic Accident*	*Safety Concern*	*Supportive Social Norms*
	Coeff. (S.E.)	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**
Psychological Indicators					
I_1: *Injury Concern*	-	-	-	1.000 (0.000)	-
I_2: *Accident Concern*	-	-	-	0.769** (0.110)	-
I_3: *Recreational Risk*	-	-	-	0.355** (0.097)	-
I_4: *Should Walk*	-	-	-	-	1.000 (0.000)
I_5: *Support Walking*	-	-	-	-	0.590** (0.187)

Note: † p<0.10, * p<0.05, ** p<0.01; The model is over identified with 88 free parameters and 24 observed variables (88 < 0.5*25*(25+1)).

Table A-11. Direct, Indirect, and Total Effects of Urban Form Measures on the Utilitarian Walking Frequency

	Effect on Traffic Accident	***Effect on the Utilitarian Walking Frequency***		
		Indirect Effect	***Direct Effect***	***Total Effect***
Net FAR	-	-	-	-
Land Use Diversity	-	-	0.737	0.737
Intersection Density	-4.180	(-4.180) * (-0.004) = 0.017	0.115	0.132
Open Space Density	-0.514	(-0.514) * (-0.004) = 0.002	-	0.002
Trail Length	-	-	-	-
Hilliness	-2.594	(-2.594) * (-0.004) = 0.010	-	0.010
Accessibility to Retail	21.129	(21.129) * (-0.004) = -0.085	0.737	0.652
Accessibility to Transit	-	-	-	-
Speed Limit	0.666	(0.666) * (-0.004) = -0.003	0.024	0.021
AM Traffic Volume	0.570	(0.570) * (-0.004) = -0.002	-	-0.002

Table A-12. Direct, Indirect, and Total Effects of Urban Form Measures on the Likelihood of Being in Non-active Recreational Walking Group

	Effect on Traffic Accident	***Effect on the Likelihood of Being in Non-active Recreational Walking Group***		
		Indirect Effect	***Direct Effect***	***Total Effect***
Net FAR	-	-	-	-
Land Use Diversity	-	-	-	-
Intersection Density	-4.180	(-4.180) * (0.018) = -0.075	-	-0.075
Open Space Density	-0.514	(-0.514) * (0.018) = -0.009	-	-0.009
Trail Length	-	-	-	0.000
Hilliness	-2.594	(-2.594) * (0.018) = -0.047	-	-0.047
Accessibility to Retail	21.129	(21.129) * (0.018) = 0.380	-	0.380
Accessibility to Transit	-	-	-1.710	-1.710
Speed Limit	0.666	(0.666) * (0.018) = 0.012	-	0.012
AM Traffic Volume	0.570	(0.570) * (0.018) = 0.010	-	0.010

Table A-13. Utilitarian Walking Model Results Without Latent Variables (N = 914)

Endogenous Variables	With Latent Variables		Without Latent Variables	
	Number of Utilitarian Walking	Traffic Accident	Number of Utilitarian Walking	Traffic Accident
	Coeff. (S.E.)	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**
Endogenous Variables				
Traffic Accident	-0.004* (0.002)	-	-0.004* (0.002)	-
Safety Concern	-0.131** (0.049)	-	-	-
Supportive Social Norms	0.109* (0.043)	-	-	-
Exogenous Variables				
Net FAR	0.010 (0.021)	0.021 (0.987)	0.016 (0.021)	0.021 (0.987)
Land Use Diversity	0.737** (0.241)	-5.480 (5.384)	0.736** (0.238)	-5.468 (5.384)
Intersection Density	0.115* (0.057)	-4.180** (1.557)	0.100† (0.057)	-4.180** (1.557)
Open Space Density	-0.005 (0.005)	-0.514** (0.109)	-0.008† (0.005)	-0.514** (0.109)
Trail Length	-0.069 (0.155)	7.102 (5.660)	-0.016 (0.156)	7.100 (5.660)
Hilliness	-0.042 (0.030)	-2.594** (0.746)	-0.048 (0.029)	-2.594** (0.746)
Accessibility to Retail	0.737* (0.289)	21.129* (9.320)	0.677* (0.272)	21.133* (9.320)
Accessibility to Transit	0.174 (0.136)	0.831 (3.565)	0.169 (0.136)	0.830 (3.565)
Speed Limit	0.024** (0.008)	0.666** (0.196)	0.022** (0.008)	0.666** (0.196)
AM Traffic Volume	0.001 (0.002)	0.570** (0.040)	0.001 (0.002)	0.570** (0.040)
High-Income	-0.153† (0.085)	-	-0.054 (0.078)	-
Mid-Income	-0.082 (0.075)	-	-0.027 (0.070)	-
Disability	-0.445** (0.151)	-	-0.522** (0.153)	-
Employ	-0.004 (0.053)	-	-0.011 (0.052)	-
Male	0.010 (0.049)	-	0.009 (0.049)	-
Own a Dog	0.145† (0.082)	-	0.157† (0.083)	-
Own a Bike	0.084 (0.053)	-	0.097† (0.052)	-
Own a Car	-0.182** (0.060)	-	-0.192** (0.061)	-

Note: † p<0.10, * p<0.05, ** p<0.01

Table A-14. Recreational Walking Model Results Without Latent Variables (N = 914)

Endogenous Variables	With Latent Variables			Without Latent Variables		
	Likelihood of being in Non-active group	*Number of Recreational Walking*	*Traffic Accident*	*Likelihood of being in Non-active group*	*Number of Recreational Walking*	*Traffic Accident*
	Coeff. (S.E.)	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**	**Coeff. (S.E.)**
Endogenous Variables						
Traffic Accident	0.018* (0.007)	0.001 (0.002)	-	0.018* (0.008)	0.002 (0.002)	-
Safety Concern	0.323† (0.171)	0.040 (0.059)	-	-	-	-
Supportive Social Norms	-0.419** (0.134)	0.051 (0.037)	-	-	-	-
Exogenous Variables						
Net FAR	0.062 (0.083)	0.068** (0.021)	0.021 (0.987)	0.056 (0.080)	0.068** (0.021)	0.021 (0.987)
Land Use Diversity	0.364 (1.077)	1.087** (0.289)	-5.480 (5.384)	0.250 (1.077)	1.080** (0.285)	-5.480 (5.384)
Intersection Density	-0.492† (0.279)	-0.007 (0.071)	-4.180** (1.557)	-0.376† (0.264)	-0.011 (0.071)	-4.180** (1.557)
Open Space Density	-0.009 (0.017)	0.008† (0.005)	-0.514** (0.109)	0.000 (0.016)	0.008† (0.005)	-0.514** (0.109)
Trail Length	-0.260 (0.720)	-0.161 (0.209)	7.102 (5.660)	-0.455 (0.748)	-0.162 (0.210)	7.100 (5.660)
Hilliness	0.008 (0.114)	-0.048 (0.033)	-2.594** (0.746)	0.021 (0.109)	-0.045 (0.033)	-2.594** (0.746)
Accessibility to Retail	-1.516 (2.165)	-0.324 (0.392)	21.129* (9.320)	-1.137 (1.732)	-0.289 (0.381)	21.133* (9.320)
Accessibility to Transit	-1.710* (0.794)	0.090 (0.152)	0.831 (3.565)	-1.791* (0.895)	0.084 (0.155)	0.830 (3.565)
Speed Limit	-0.030 (0.033)	0.002 (0.010)	0.666** (0.196)	-0.028 (0.033)	0.001 (0.010)	0.666** (0.196)
AM Traffic Volume	-0.011 (0.009)	-0.005* (0.002)	0.570** (0.040)	-0.015 (0.010)	-0.005* (0.002)	0.570** (0.040)
High-Income	0.030 (0.376)	0.078 (0.102)	-	0.351 (0.314)	0.068 (0.093)	-
Mid-Income	-0.094 (0.326)	0.037 (0.096)	-	-0.314 (0.298)	0.026 (0.090)	-
Disability	0.540 (0.428)	-0.286† (0.157)	-	0.791† (0.403)	-0.286† (0.159)	-
Employ	0.294 (0.229)	-0.221** (0.067)	-	0.358 (0.224)	-0.222** (0.066)	-
Male	0.187 (0.218)	0.017 (0.062)	-	0.252 (0.205)	0.008 (0.061)	-
Own a Dog	-0.354 (0.342)	0.580** (0.083)	-	-0.337 (0.349)	0.569** (0.082)	-
Own a Bike	-0.062 (0.236)	0.026 (0.068)	-	-0.073 (0.243)	0.022 (0.068)	-
Own a Car	-0.261 (0.264)	-0.151† (0.088)	-	-0.313 (0.260)	-0.155† (0.089)	-

Note: † p<0.10, * p<0.05, ** p<0.01

Table A-15. Example Mplus Codes (Recreational NMT Model)

```
DATA:        File is BOOMERS_WEIGHT.dat ;

VARIABLE:    NAMES ARE
             rp_child rp_sidew rp_spwlk rp_space rp_simip rp_stran rp_nhsps rp_neism
             rp_valsp zp_child zp_sidew zp_spwlk zp_space zp_simip zp_stran zp_nhsps
             zp_neism zp_valsp z_child z_sidew z_spwlk z_space z_simip z_stran
             z_nhsps z_neism z_valsp NWalk NNei Walk NoWalk Nei NoNei pid hhid NDID
             Grid Loop Linear RC ThreeVeh Bike Healthy Age Employ Male NHInc NMInc
             NLInc DwDen IntDen SideWalk Dest400 MBTA Commuter Dest
             WE1 WE3 WE5 ;

             Missing are all (-9999) ;

             USEVARIABLES
             NWalk
             RC Grid Loop
             Employ Healthy Male Age  NHInc NMInc ThreeVeh Bike
             IntDen Dest Dest400 MBTA Commuter
             rp_child rp_sidew rp_spwlk rp_space rp_simip
             rp_stran rp_nhsps rp_neism rp_valsp Street ;

             COUNT IS NWalk(nbi) ;                                     !ZINB Model

             CATEGORICAL IS RC ;

             WEIGHT = WE3 ;                                            !3.2% Weight

             CLUSTER = hhid ;                                          !Cluster Option

ANALYSIS:    !Maximum likelihood estimator with robust standard error
             ESTIMATOR = MLR ;
             TYPE=COMPLEX ;

MODEL:       !Measurement Model
             RP1 by rp_spwlk rp_valsp rp_nhsps rp_space rp_sidew;      !Pro Walkability
             RP2 by rp_neism rp_simip rp_stran rp_child;               !Pro Segregation

             !Structural Model
             RP1 ON Employ Healthy Male Age NHInc NMInc ThreeVeh Bike ;
             RP2 ON Employ Healthy Male Age NHInc NMInc ThreeVeh Bike ;
```

RC ON RP1 RP2
Loop IntDen Dest Dest400 MBTA Commuter Street
Employ Healthy Male Age NHInc NMInc ThreeVeh Bike ;

NWalk ON
RC RP1 RP2 Grid Loop
IntDen Dest Dest400 MBTA Commuter Street
Employ Healthy Male Age NHInc NMInc ThreeVeh Bike ;

NWalk#1 ON
RC RP1 RP2 Grid Loop
IntDen Dest Dest400 MBTA Commuter Street
Employ Healthy Male Age NHInc NMInc ThreeVeh Bike ;

Table A-16. Example Mplus Codes (Utilitarian Walking Model)

```
TITLE:       Urban Boomers SEM ;

DATA:        File is NewSEMData_400m.dat ;

VARIABLE:    NAMES ARE
             ID RID CAR BIKE DOG AGE
             MALE EMPLOY DISABIL HINC MINC LINC
             WALK_NON WALK_UTL WALK_EXE
             NETFAR2 DI2 INTDST2 OPENDST2 TRAIL2 SLOPE2
             ACCRTL2 ACCTRAN2 FREE2
             CRSH08 CRSH07 CRSH06 CRSH05 AVECRSH VAM2 CRATE2 CRATE
             WE_SAFE WS_SAFE
             NORM_WLK NORM_SUP
             A_WLKINJ A_WLKACC

             USEVARIABLES
             WALK_UTL
             A_WLKINJ A_WLKACC WS_SAFE
             NORM_WLK NORM_SUP
             CAR BIKE DOG MALE EMPLOY DISABIL HINC MINC
             NETFAR2 DI2 INTDST2 OPENDST2 TRAIL2 SLOPE2
             ACCRTL2 ACCTRAN2 FREE2 AVECRSH VAM2 ;

             COUNT IS WALK_UTL(nb);                   !Negative Binomial Model

             CLUSTER = RID ;                          !Cluster Option

DEFINE:      WS_SAFE = 6 - WS_SAFE;
             OPENDST2 = OPENDST2 *100 ;
             VAM2 = VAM2 / 1000 ;

ANALYSIS:    !Maximum-likelihood estimator with robust standard error
             ESTIMATOR = MLR;
             TYPE = COMPLEX ;

MODEL:       !Measurement Model
             RP1 by A_WLKINJ A_WLKACC WS_SAFE;        !Safety Concern
             RP2 by NORM_WLK NORM_SUP;                !Supportive Norm

             !Structural Model
             WALK_UTL ON
```

```
RP1 RP2
HINC MINC DISABIL EMPLOY MALE DOG BIKE CAR
AVECRSH
NETFAR2 DI2 INTDST2 OPENDST2 TRAIL2 SLOPE2
ACCRTL2 ACCTRAN2 FREE2 VAM2 ;

AVECRSH ON
NETFAR2 DI2 INTDST2 OPENDST2 TRAIL2 SLOPE2
ACCRTL2 ACCTRAN2 FREE2 VAM2 ;

RP1 ON
HINC MINC DISABIL EMPLOY MALE DOG BIKE CAR ;

RP2 ON
HINC MINC DISABIL EMPLOY MALE DOG BIKE CAR ;
```

Figure A-1. Suburban Survey Instrument: Information Letter (This letter was included with the survey instrument; Shown at 85% reduction).

Department of Urban Studies & Planning
77 Massachusetts Avenue
Room 10-485
Cambridge, MA 02139

Massachusetts Institute of Technology

To Whom It May Concern:

A survey is being undertaken as part of a research project examining the travel activities of the Boston Metropolitan Area, which we hope will bring benefit to residents in the future.

You have been randomly selected as one of 7,000 residents to participate in the survey. Your participation is voluntary but we hope you will choose to contribute to the efforts and enjoy doing so. Please keep the enclosed $5.00 as a small thanks in advance for your participation.

Enclosed you will find a survey in two Sections. The First Section asks some general questions about your household, residential preferences, etc. This should be filled out by the head(s) of household. The Second Section includes several travel diaries, to be completed by each household member. The purpose of this diary is to record the daily travel activities on a typical weekday. Please follow the instructions on the first page of the diary.

All information obtained in this survey will be treated with absolute confidentiality and it will not be possible for the researchers to identify the respondents in any way. We would greatly appreciate complete and candid answers to all of the questions. You may, however, decline to answer any and all questions in this survey and otherwise decline to participate if you so desire and without any adverse consequences.

Enclosed please find a self-addressed, postage paid envelope to return the completed materials. We request that you complete and return the surveys within two (2) weeks.

If you have any questions about this survey instrument, contact the principal researcher: Chris Zegras at 617 452 2433. If you have any questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143b, 77 Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253-6787, e-mail: mede@med.mit.edu.

Thank you. Your cooperation in this survey will be valuable.

Sincerely,

P. Christopher Zegras
Asst. Professor of Transportation and Urban Planning

Figure A-2. Suburban Survey Instrument: Suburban Baby Boomer Household Survey (Shown at 80% Reduction).

Travel Behavior Research Project Survey

Massachusetts Institute of Technology

Your Travel Diary Booklet

Thank you for taking part in this survey. Your participation will help researchers at the Massachusetts Institute of Technology in a project aiming to better comprehend household travel activities. All responses are voluntary, anonymous and will be kept strictly confidential. Please refer to the accompanying letter for more information about the survey and your privacy.

This booklet is a travel diary. There are two copies in this envelope. A resident adult should fill in one copy independently. If there is a second adult who lives here, he or she should fill out the second booklet.

Completing your travel diary

This booklet contains two parts:

<u>Section 1: Background information (pages 2 - 5)</u>
This section contains questions about your occupation, attitudes and daily trips. You can fill out this section anytime.

<u>Section 2: Travel Diary (page 5 onwards)</u>
The travel diary should be completed on a single day. Please fill it out on the first Tuesday, Wednesday or Thursday after receiving this survey. For example, if this survey arrives in the mail on Saturday, fill out the diary on Tuesday.

Section 1: Background Information

1 Questions about you

a How old are you? *write your age (e.g. 54)*

__________ years

b Are you male or female?

[Male] [Female]

c What is your relationship to the principal wage earner?
mark one answer only

[I am the principal wage earner] [Other (write in below)]

d Relationship: ______________________________

e Which phrase best describes your current situation?
mark one answer only

[Employed full time] [Employed part time]

[Retired] [Homemaker] [Seeking work]

Figure A-2. Suburban Survey Instrument: Suburban Baby Boomer Household Survey (Shown at 80% Reduction).

2 Questions about your health

Having health problems may prevent you from making journeys or affect the types of journeys that you make. Because of a physical, mental, or emotional problem do any of the following statements apply to you?

Check all boxes that apply.

☐ My health problems keep me from working at a job.

☐ My health problems restrict the kind or amount of work I do.

☐ I am limited in some way in any activities because of my health problems .

☐ I need the help of other persons with personal care needs, such as eating, bathing, dressing, or getting around inside your home.

☐ I need the help of other persons in handling routine needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes.

☐ None of the statements above apply to me.

3 Questions about your travel attitudes

For each statement, express your level of agreement.
1 = strongly disagree, 3 = neutral, 5 = strongly agree

a I enjoy driving
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

b I make efforts to minimize the amount of driving I need to do
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

c I like riding a bus
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

d I enjoy bicycling
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

e Taking public transit is convenient
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

f Highways deserve more investment than public transit.
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

g I prefer to combine multiple activities into a single journey
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

h Having sidewalks make me more likely to walk
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

i I dislike sitting in traffic
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

j The price of gasoline should be increased to reduce congestion.
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

Figure A-2. Suburban Survey Instrument: Suburban Baby Boomer Household Survey (Shown at 80% Reduction).

4 **Questions about regular journeys you make**

Last week (Monday to Sunday), how many times did you make the following one way trips?

a Drive to work

0 1 2 3 4 5 6 7 8 9+

b Go to work on public transportation

0 1 2 3 4 5 6 7 8 9+

c Walk or cycle for exercise in your neighborhood

0 1 2 3 4 5 6 7 8 9+

d Travel to another area for exercise

0 1 2 3 4 5 6 7 8 9+

e Transport someone (pickup, drop off)

0 1 2 3 4 5 6 7 8 9+

f Go shopping

0 1 2 3 4 5 6 7 8 9+

g Visit a neighbor

0 1 2 3 4 5 6 7 8 9+

h Visit a friend in a different neighborhood

0 1 2 3 4 5 6 7 8 9+

i Go out for recreation (sports, eating out, movies)

0 1 2 3 4 5 6 7 8 9+

j If you work, how much total time (i.e., round trip, door to door) do you spend commuting to and from work on a typical working day?
write in number of minutes (e.g. "45 minutes")

Duration of commute: ____________________

k In a typical week, how many miles do you travel in a car (as driver or passenger)? *write in number of miles (e.g. 30 miles)*

Total miles: ____________________

m Do you have a MBTA commuter rail monthly pass?

Yes No

n Do you have a MBTA CharlieCard pass?

Yes, monthly pass Yes, weekly pass No

Figure A-2. Suburban Survey Instrument: Suburban Baby Boomer Household Survey (Shown at 80% Reduction).

h Are you considering moving to a new home?
choose one

- In the next few years
- Not now, but maybe in the future
- I will not move

When thinking about moving to a new home in the future, what do you consider as important influences on the decision?
1 = not important, 3 = neutral, 5 = very important

i Downsizing to smaller home
1 2 3 4 5
not important — *neutral* — *very important*

j Current home becoming less practical
1 2 3 4 5
not important — *neutral* — *very important*

k Health/aging concerns
1 2 3 4 5
not important — *neutral* — *very important*

m Living closer to family
1 2 3 4 5
not important — *neutral* — *very important*

n Living closer to shops and services
1 2 3 4 5
not important — *neutral* — *very important*

p Living closer to work
1 2 3 4 5
not important — *neutral* — *very important*

q Living closer to schools/other education facilities
1 2 3 4 5
not important — *neutral* — *very important*

6 **Questions about your residential preferences**

For each statement, express your level of agreement.
1 = strongly disagree, 3 = neutral, 5 = strongly agree

a I like to live in a neighborhood with children in it
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

b I prefer a house close to the sidewalk so that I can see and interact with passersby
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

c I prefer to have shops and services within walking distance
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

d I prefer a lot of space between my home and the street
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

e I prefer living around people who are similar to me
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

f I am concerned about strangers walking through my neighborhood
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

g I like a neighborhood containing housing, shops and services
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

h I prefer neighbors at the same stage of life as me
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

i I value space around my home more than having shops nearby
1 2 3 4 5
strongly disagree — *neutral* — *strongly agree*

Figure A-3. Urban Survey Instrument: Information Letter (This letter was included with the survey instrument. Shown at 75% reduction).

Massachusetts Institute of Technology

Department of Urban Studies & Planning
77 Massachusetts Avenue
Room 10-485
Cambridge, MA 02139

To Whom It May Concern:

We are carrying out a survey as part of a research project examining the travel activities of residents in the Boston Metropolitan Area, which we hope will bring benefit to residents in the future.

Your household has been randomly selected as one of 7,000 potential participants in this survey. You were selected as a possible participant in this study because you are a resident of an urban neighborhood in the Boston metropolitan area. Your participation is completely voluntary, but we hope that you will choose to contribute to our efforts and enjoy doing so.

Enclosed you will find two booklets.

- *If you are the only adult living in your home, please complete Booklet #1 only.*
- *If there are two adults living in your home, please have the oldest adult complete a booklet and the second oldest complete the other booklet.*

After you have filled out the booklet(s), please return them in the enclosed self-addressed, postage paid envelope. We request that you complete and return the surveys within two (2) weeks. All information obtained in this survey will be treated with absolute confidentiality. Your addresses will be eliminated and it will not be possible for the researchers to identify the respondents in any way.

We would greatly appreciate complete and candid answers to all of the questions. You may, however, decline to answer any and all questions in this survey and otherwise decline to participate if you so desire and without any adverse consequences.

If you have any questions about this survey instrument or study, contact the principal researcher: Chris Zegras at 617 452 2433. If you have any questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143b, 77 Massachusetts Ave, Cambridge, MA 02139, phone 1-617-253-6787, e-mail: mede@med.mit.edu.

Thank you. Your cooperation in this survey will be valuable.

Sincerely,
P. Christopher Zegras
Assoc. Professor of Transportation and Urban Planning

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

Travel Behavior Research Project Survey

Booklet#1

Massachusetts Institute of Technology

Questions about your home and neighborhood

1. How long have you lived at this address?
   write in number of years and months

   ________ years ________ months

2. Including yourself, how many people live at this address?
   write in number of persons

   ________ persons

3. Do you own or rent your home? *mark one box only*

   ☐ Own
   ☐ Rent / lease
   ☐ Provided by job or military

4. If you live with your children, how many and how old are they?
   write in number of children and age of each child.
   If you do not live with your children, please leave blank

   ______children: Age of the first child ______,
   Age of the second child______,
   Age of the third child ______

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

6. How many motor vehicles do you have at your home? Include cars, motorcycles, and trucks. *mark one box only*

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 or more

7. How many bicycles do you have at your home? *mark one box only*

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 or more

8. What type of home do you live in? *mark one box only*

☐Detached single house
☐Duplex or Triple-Decker
☐Apartment building
☐Townhouse or rowhouse
☐Don't know

9. Before moving to this address, what type was your previous home? *mark one box only*

☐Detached single house
☐Duplex or Triple-Decker
☐Apartment building
☐Townhouse or rowhouse
☐Don't know

10. Do you live in a community with age restrictions on who can live there? *mark one box only*

☐Restricted (all 55+ only)
☐Not restricted
☐Not sure

11. What are reasons you chose your current home location? choose only three reasons and rank them according to importance by writing '1, 2, 3' (1 being most important).

___ Physically active lifestyle
___ Cost / price of home
___ Quality of home
___ Home or lot size
___ School system
___ Neighborhood quality
___ Convenient to work
___ Close to family and friends
___ Close to public transportation
___ Convenient to retail (e.g., shopping, restaurants, banks)

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

Questions about regular activities you make

The questions in this section are about your weekly activities (during the past seven days). For example, if today is Wednesday, the past seven days are from the past Wednesday to Tuesday (yesterday).

The questions ask the frequency of your weekly activities. If your activity is a two-way trip (e.g., from home to work and from work to home), please count it as a single activity.

In these questions, a "*neighborhood*" indicates an area within about one mile from your home.

1. During the past seven days, *how many times* did you ***walk*** for the following activities? *circle one number only*

Go to work from your home:

0 1 2 3 4 5 6 7 8 9 10 11 12+

Go out for nonwork purposes (e.g., shopping, eating, errand, etc):

0 1 2 3 4 5 6 7 8 9 10 11 12+

Walk for exercise or a stroll in your neighborhood

0 1 2 3 4 5 6 7 8 9 10 11 12+

2. During the past seven days, *how much total time* did you spend ***walking***? *write in number of hours and minutes*

__________ hours __________ minutes

3. During the past seven days, *how many times* did you ***bike*** for the following activities? *circle one number only*

Go to work from your home:

0 1 2 3 4 5 6 7 8 9 10 11 12+

Go out for nonwork purposes (e.g., shopping, eating, errand, etc):

0 1 2 3 4 5 6 7 8 9 10 11 12+

Bike for exercise or leisure in your neighborhood

0 1 2 3 4 5 6 7 8 9 10 11 12+

4. During the past seven days, *how much total time* did you spend ***biking***? *write in number of hours and minutes*

__________ hours __________ minutes

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

5. During the past seven days, *how many times* did you ***drive as a driver*** for the following activities?

Go to work from your home:

0 1 2 3 4 5 6 7 8 9 10 11 12+

Go out for nonwork purposes (e.g., shopping, eating, errand, etc):

0 1 2 3 4 5 6 7 8 9 10 11 12+

6. During the past seven days, *how many times* did you ***ride in a private motor vehicle (e.g., car, truck) as a passenger*** for the following activities?

Go to work from your home:

0 1 2 3 4 5 6 7 8 9 10 11 12+

Go out for nonwork purposes (e.g., shopping, eating, errand, etc):

0 1 2 3 4 5 6 7 8 9 10 11 12+

7. During the past seven days, *how many times* did you take ***subway, bus, or commuter rail*** for the following activities?

Go to work from your home:

0 1 2 3 4 5 6 7 8 9 10 11 12+

Go out for nonwork purposes (e.g., shopping, eating, errand, etc):

0 1 2 3 4 5 6 7 8 9 10 11 12+

8. During the past seven days, *how many times* did you take ***taxi, shuttle bus, or dial-a-ride*** for the following activities?

Go to work from your home:

0 1 2 3 4 5 6 7 8 9 10 11 12+

Go out for nonwork purposes (e.g., shopping, eating, errand, etc):

0 1 2 3 4 5 6 7 8 9 10 11 12+

The three questions below are about your neighborhood activities. In these questions, a "*neighborhood*" indicates an area within about one mile from your home, and "*neighbors*" include friends and family members who live in your "*neighborhood*."

9. During the past seven days, how many times did you ***visit your neighbors***?

0 1 2 3 4 5 6 7 8 9 10 11 12+

10. During the past seven days, *how many times* did you ***go out with your neighbors for shopping, restaurant, or entertainment*** in your neighborhood?

0 1 2 3 4 5 6 7 8 9 10 11 12+

11. Last week (Monday to Sunday), *how many times* did you ***hang out, stroll, or walk with your neighbors*** in your neighborhood?

0 1 2 3 4 5 6 7 8 9 10 11 12+

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

Questions about neighborhood satisfaction

1. How satisfied are you with your quality of life in your current neighborhood? Please rate your overall level of satisfaction.

   Least Satisfied 1 2 3 4 5 Most Satisfied

2. From your experience, what factors contribute to being satisfied with your neighborhood? Please rate ***the level of importance*** and ***the level of satisfaction*** of the following factors to you.

	Level of Importance					Level of Satisfaction				
	Less Important		Neutral		More Important	Less Satisfied		Neutral		More Satisfied
Neighborliness (social activities and interaction)	1	2	3	4	5	1	2	3	4	5
Age integration (community with diverse age groups)	1	2	3	4	5	1	2	3	4	5
Cost / price of home (monetary assistance and/or low rent)	1	2	3	4	5	1	2	3	4	5
Large home	1	2	3	4	5	1	2	3	4	5
Large lot size	1	2	3	4	5	1	2	3	4	5
School system (good public and private schools)	1	2	3	4	5	1	2	3	4	5
Convenient to work (close to work places)	1	2	3	4	5	1	2	3	4	5
Close to public transit (bus, subway, and commuter rail)	1	2	3	4	5	1	2	3	4	5

	Level of Importance					Level of Satisfaction				
	Less Important		Neutral		More Important	Less Satisfied		Neutral		More Satisfied
Convenient to retail/services (stores, banks, and hospitals)	1	2	3	4	5	1	2	3	4	5
Safety from traffic (low speeds and low accident rate)	1	2	3	4	5	1	2	3	4	5
Security from crime (low crime rate)	1	2	3	4	5	1	2	3	4	5
Noise level (peaceful environment)	1	2	3	4	5	1	2	3	4	5
Air quality (free from pollution)	1	2	3	4	5	1	2	3	4	5
Recreational facilities (parks and pathways)	1	2	3	4	5	1	2	3	4	5
Community facilities (community and senior center)	1	2	3	4	5	1	2	3	4	5
Walking-friendly features (ramps and benches)	1	2	3	4	5	1	2	3	4	5
Other: ______	1	2	3	4	5	1	2	3	4	5

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

Questions about your travel experiences

circle one number for each evaluative word pair

1. For me, the experience of walking for exercise or a leisure stroll would overall be:

A bad experience	1	2	3	4	5	A good experience
Unsafe	1	2	3	4	5	Safe
Bad for my health	1	2	3	4	5	Good for my health
Physically difficult	1	2	3	4	5	Physically easy

2. For me, the experience of walking to get to shopping or errands would overall be:

A bad experience	1	2	3	4	5	A good experience
Unsafe	1	2	3	4	5	Safe
Bad for my health	1	2	3	4	5	Good for my health
Physically difficult	1	2	3	4	5	Physically easy
Good for the environment	1	2	3	4	5	Bad for the environment

	Unlikely				Likely
3. Most people who are important to me think that I should walk.	1	2	3	4	5
4. Most people who are important to me would support me if I chose to walk rather than to drive.	1	2	3	4	5

	Strongly Disagree				Strongly Agree
5. I am confident that I can walk by myself in my neighborhood if I wanted to walk.	1	2	3	4	5
6. I feel more confident about walking if I am going with someone or walking a pet.	1	2	3	4	5
7. If I wanted to walk, I am unlikely to do it because I am concerned about falling or injuring myself.	1	2	3	4	5
8. If I wanted to walk, I am unlikely to do it because I am concerned about being in an accident with cars.	1	2	3	4	5
9. Getting to my destination as fast as possible is my main goal when deciding how I travel.	1	2	3	4	5
10. I do not feel personally responsible for the environmental impacts resulting from car use.	1	2	3	4	5
11. I feel guilty about using a car when I have the choice to walk or use public transit instead.	1	2	3	4	5
12. I feel that society's transportation patterns are seriously harming our planet.	1	2	3	4	5
13. My daily travel makes up a large share of my total impact on the environment.	1	2	3	4	5

Figure A-4. Urban Survey Instrument: Urban Baby Boomer Household Survey (Shown at 85% Reduction).

Questions about you

1. How old are you? *write your age (e.g. 56)*

   ______ years

2. Are you male or female? *mark one box only*

   ☐ Male ☐ Female

3. Which phrase best describes your current situation?
   mark one box only, or leave blank if you prefer

   ☐ Employed full time
   ☐ Employed part time
   ☐ Seeking work
   ☐ Retired
   ☐ Homemaker
   ☐ Volunteer

4. How would you describe your racial/ethnic background?
   mark one answer only, or leave blank if you prefer

   ☐ White
   ☐ Black / African American / Caribbean
   ☐ American Indian / Alaskan Native
   ☐ East Asian
   ☐ South Asian
   ☐ Native Hawaiian / Pacific Islander
   ☐ Other______

5. Last year, what was your total household income, from all sources before tax? *mark one answer only, or leave blank if you prefer*

   ☐ Less than $15,000
   ☐ $15,000 - 24,999
   ☐ $25,000 - 34,999
   ☐ $50,000 - $74,999
   ☐ $50,000 - $74,999
   ☐ $75,000 - $99,999
   ☐ $100,000 - $149,999
   ☐ $150,000 or more

6. Do you have a disability or health condition that has lasted 6 or more months and which makes it difficult to go outside the home alone—for example, to shop or visit a doctor's office?
   mark one answer only, or leave blank if you prefer

   ☐ Yes ☐ No

7. If you have any comments on your neighborhoods and activities, please write below. If you need more space, you may use the top of the next page.

   ____

Thank you for your participation.

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